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MUCH of the improvement of airplanes has been directed toward the reduction of resistance, and consequently the gliding angle. That this is not an unmixed blessing has been found the case with racing machines, where an inordinately large field is required to land in. For cross country work the ability to get into a small space surrounded by obstacles necessitates taking a steep flight path without increasing the speed. The resistance which has been so carefully decreased must be supplied again to keep the speed down during the glide.

An obvious method of accomplishing this result, but one which has never attained popularity, is by means of air brakes. Serious study of this device would undoubtedly produce a useful brake.

But there are other ways of increasing the drag. One is to increase the camber of the wings. At the same time a second benefit may be derived through raising the lift coefficient of the wings, thus cutting down the low speed. A writer in this issue proposes a very ingenious solution of this problem.

Amphibian Development

The recent British competition for amphibians or combined land and water airplanes has produced some interesting machines. Of these the most original is a large flying boat equipped with a central engine room from which bevel gear shafts drive the two propellers. The power plant is composed of four engines, arranged in pairs on either side, and with the engines of each pair facing one another with what would normally be their propeller ends. A system of gear boxes and multiple disc clutches allows each of the two propellers to be driven with either or both engines of each pair, so that the risk attendant to engine failure is really reduced to a minimum. Furthermore, as the engines in question are fitted with a flywheel, they can be run free for purposes of testing, whereby much vibration is avoided in gearing and shafting.

While this system of propulsion is still in its infancy, it would seem to be the right step toward making multiple engine airplanes more reliable in operation. The weight of the clutches and gear boxes is, of course, bound to add to the dead weight of the machine, but if the result be greatly increased dependability, the cost does not seem too great for such an improvement.

Another point of note in the amphibian competition just mentioned is that the majority of competitors entered machines which are primarily flying boats and only secondarily land machines. That is to say, the British amphibians are intended to fly mainly over water and to alight only occasionally on land. This is logical after all, for it seems very difficult to make the amphibian a compromise machine which would work equally satisfactorily on both land and water. Since the flying boat is probably the best type for large marine airplanes, the landing gear of large amphibians must be looked upon as an accessory to be used in emergency only, for to land a big flying boat habitually on an aerodrome would quickly strain the hull to such extent that it would spring a leak.

For smaller machines it is however conceivable that a type might be developed which could land equally well on land and water, for in this case a float type seaplane could be used and the landing gear could be made very sturdy since it would be be called upon to carry both wheels and floats.

Comfort in Flying

Flying sickness is generally expected only on one's first flights, but experiences at the recent Air Ministry Competitions indicate that it is possible for an aviator with a record of several hundred hours in the air to be overcome with this malady. Some of the observers and passengers found the reliability tests of three and one half hours' duration to be much too long for comfort in the enclosed cabins of the competing machines, while the pilot in the cockpit exposed to the airstream was quite at ease.

There is a suspicion that the ventilation of the cabins was inadequate and that a slight leakage of exhaust gases from the heating devices added to the discomfort. Certainly there is room for improvement in the art of cabin design when sickness is promoted rather than prevented by riding inside.

One of the considerations in favor of making the London-Paris trip by air is to avoid the rough channel crossing. But probably as large a proportion of the passengers are as air sick as seasick in making the journey by air and water respectively, so that if it is impossible to obviate this undesirable characteristic of air travel, its prestige must suffer.

The remedy naturally lies with an efficient ventilation system which would constantly supply fresh air to the cabin and drive out such gas fumes as might find their way into the passenger accomodations.

Another factor which probably contributes at times to give passengers unaccustomed to flying this malady is the noise and vibration produced by the power plant. This again offers to the aeronautical designer a field for much improvement and one which should immediately be tackled, for the more comfort the passenger will find in air transport, the more he will come to look upon this mode of locomotion as the natural rapid transit system for great distances.

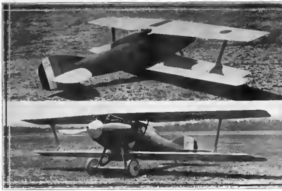
It would be a good thing for commercial aviation if some aeronautical organization or engineering society would offer a few prizes for the development of an efficient silencer for aircraft engines and a sound and vibration proof cabin.

Safety Features

Reports of the successful application of brakes to the wheels of several entrants to the Air Ministry Competitions have been received with great interest. These brakes are accompanied by a leading wheel or wheels not used in a normal landing, but to prevent nosing over under too severe braking. These forward wheels will no doubt prove of value in a forced landing, but it has been found possible to pull up the machines quite sharply without bringing them into play. The device is quite simple in design and operation and may increase rapidly in popularity.

Another tendency noted is the improvement of the gasoline system in point of safety. Crash-proof tanks and tanks slung below the wings at some distance from the motor and occupants are noticeable features.

Gordon Bennett Entry of the U. S. Air Service



TWO VIEWS OF THE V C P RACER OF THE U S AIR SERVICE
U S Army Air Service Photo

The U S Air Service in its entry in the Gordon Bennett International Airplane Race of 1920 may be said to be more truly represented than possibly any other competitor This is because the Army of the United States traditionally represents the country as no other organization can, and the machine entered by the Army Air Service is truly an Army airplane, designed first of all as a "chasse" 'plane for war purposes, by a member of the Air Service. Fully in keeping with the details recorded above, is the fact that the pilot of this airplane was none other than Major R W. Schroeder, justly famous for his past altitude work and now holder of the world's altitude record.

The main and outstanding characteristics of the airplane itself is that it embodies all of those features, which have come to be known among airplane designers as making for speed and efficiency Every portion of the machine that can be, has been carefully streamlined from the nose projecting beyond the propeller hub to the fairing placed behind the pilot's head, and the vertical stabilizer which like some of it's European sisters is built integral with the fuselage The horizontal stabilizer is carefully faired into the sides of the fuselage, which itself is of the pisciform, monocoque type The wing construction is more or less unique for American made airplanes in that the upper wing is continuous, there being no "center-section," and the inter-plane bracing consisting only of one strut on either side of the fuselage, together with the four crossed flying and landing wires, which gives the proper incidence setting to the wing section The only other struts are the four "chandels," which support the center of the top wing at the fuselage above the pilot and power plant. The two main struts mentioned are similar to those employed in the Spad Herbemont, though possibly slightly wider The ailerons are of the balanced type and appear only on the lower wing

The airplane has been known to the Air Service as the "Verville Scout" and is the same as herein described except that for the usual Hispano-Suiza engine, a new 12-cylinder Packard has been substituded. The main dimensions are: spread 28 ft. 2 in, over-all length 24 ft 2 in., over-all height 8 ft 8 in, weight empty 2485 lb, fuel and oil 536 lb., pilot 180 lb, parachute 12 lb, instruments and equipment 20 lb, making a total of 3233 lb The weight per square foot of wing surface is 14.12, per horsepower slightly over 5 lb, endurance full throttle is 1 hr 15 min

Wings. The wings, set at small differential angles of incidence, are built on the R.A F 15 curve and have a total area, including the ailerons, of 228.5 sq. ft The stagger is 18 in. The upper plane has a span of 27 ft 6 in., with a tapering chord of from 72 in to 42 in, and an area of 127 sq ft. The lower plane has a total span of 26 ft. 2 in., and the chord varies from slightly over 66 in to 42 in, with an area of 101.5 sq ft., including the ailerons The two ailerons have an area of 18 5 sq ft each. In the upper wing are incorporated the gravity, gasoline and radiator expansion tanks The alignment is secured by adjusting the turn buckles attached to the spar fittings. The strut is attached to the rectangular compression rib The lower wings are hinged to the wing butt which is faired into the fuselage Heavy transfer members in

the bottom of the fuselage transmit stresses in the lower wing

Spars. The spars are built up of two spruce channel sections, joined back to back, with three-ply wood between and three-ply covering the sides Spars are tapered from root to tip The upper surface of the leading edge of the wing as far back as the front spar is reinforced with three-ply

Aileron Control System. The aileron control system is of the rigid or positive type The torque tube is operated by a linkage which maintains a positive connection between each aileron to the control stick

Stabilizers The horizontal stabilizer has an area of 18 sq. ft. and has no angle of incidence

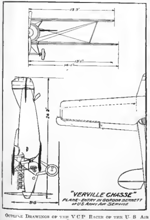
Elevator The elevator hinged to the rear edge of the stabilizer has an area of 16 sq. ft

Rudder The rudder has an area of 9 5 sq ft

Fuselage The fuselage is of pisciform cross section maximum being 40 x 50 in and is of ply-wood

Landing Gear The landing gear is of the two wheel type, with a tread of 64-3/4 in elastic chord shock absorber system with tail skid as brake

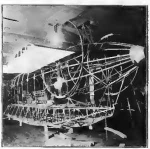
Power Plant The engine is a 12 cyl Packard rated at 578 hp. for the low compression engine and 638 hp for the high compression, at 2000 r p m Bore and stroke is 5-3/4 in x 6-1/2 in. The weight dry is 1126 lb. The ignition is Delco with battery, generator and distributor, firing two plugs per cylinder, two intake valves and two exhaust valves are used for each cylinder Radiator is of the honey-comb type, placed under the fuselage. The exhaust system comprises twelve individual pipes on each side faired off with aluminum fittings. Oil tank has capacity of 7 gal. The lubrication is by dry sump system with one pressure gear pump and two scavenging pumps. The fuel system consists of a seven-gallon tank in the center of each upper wing, a 37 gal main tank, a 23 gal forward auxiliary and a 15 gal rear auxiliary, total 485 gal Engine controls consist of throttle, spark and altitude. The tractor screw has two blades and either 9 ft or 9 ft. 2 in. diameter may be used Greatest pitch is 9.23 ft. The larger air screw is for the high compression engine and the smaller one for the low compression engine, one of each type having been shipped for the race



OUTLINE DRAWINGS OF THE V C P RACER OF THE U S AIR SERVICE

A Large Flying Boat

The accompanying illustration shows a large seaplane which is under construction at the plant of the International Aerial Navigation Co, of St Louis. The machine is designed as a tandem monoplane with a streamline fuselage which rests on a float of large capacity The length of the fuselage is 42 ft. the width 8 ft 6 in and the height 9 ft 6 in. The framework of the fuselage is constructed of nickel steel tubing and sheet aluminum is used for encasing the fuselage The joints of the fuselage are made by oxy-acetylene welding



FUSELAGE AND CENTER PONTOON OF THE NEW SEAPLANE OF THE INTERNATIONAL AERIAL NAVIGATION CO

The power plant consists of two Liberty Twelve engines, which are mounted in tandem inside of the fuselage on the deck of the pontoon and actuate two side propellers through a shaft drive The total weight, loaded, of the machine is expected to reach 26,000 lb

N. A. C. A. Reports

MOISTURE RESISTANT FINISHES FOR AIRPLANE WOODS. Synopsis of Report No 85 National Advisory Committee for Aeronautics.

This report describes briefly a series of experiments made at the Forest Products Laboratory, Madison ,Wisconsin, to determine the comparative moisture resistance of linseed oil, impregnation treatments, condensation varnishes, oil varnishes, enamels, cellulose varnishes, rubber, electroplated and sprayed metal coatings, and metal leaf coatings when applied to wood

All coatings except the rubber and electroplated metal coatings, which were not developed sufficiently to make them practical, admitted moisture in varying degrees The most effective and at the same time most practical coating was found to be that of aluminum leaf

Safety in Flight

Excerpt from a lecture delivered by Air Commander R. K. Bagnall Wild, Royal Air Force, before the Scottish Branch of the Royal Aeronautical Society during March, 1920

(Continued from our last issue)

Other Materials

Materials like plywood, glue and casein cements have also been gradually raised during the war from a condition of unreliable and irregular quality and placed on a more scientific basis. Thus the quality of glue has been improved by establishing definite test standards, and demanding the elimination of accidental and deleterious constituents. In fact, where in the early stages of inspection over 40 per cent of the glue tested was discarded because of failure to attain to the essential conditions laid down by the A. I. D., the quality of the production has so improved that 90 per cent now passes all tests.

Similarly with casein cements (generally used for the manufacture of waterproof plywood), the quality has so far been improved that the productions are not only waterproof at ordinary temperatures but may even be boiled for several hours without showing appreciable signs of separation.

The use of linen for airplane fabric has been almost universal, although cotton was employed toward the end of the war.

As far as the construction of the fabrics is concerned, it is a simple matter to ascertain that the number of threads per inch in the warp (lengthwise threads) and in the weft (crosswise threads) are such as are required by specification, while the weight per square yard of the fabric and the tensile strengths of the yarn and the woven fabric are easily determined quantities.

On the other hand, the general quality of the material may be seriously affected by a variety of weaving defects, and these often need a trained eye to detect them in the piece. Such defects are either cut out or patched.

One obscure defect took some little time to locate. In some instances a good quality dope applied to an apparently good quality fabric produced a very unsatisfactory dope surface full of minute bubbles and blisters. This was eventually traced back to the size used in the weaving process. The warp threads, which have to withstand considerable tensile stress as well as much chafing during the weaving process, are usually sized with thin flour or starch paste to which a "size softener" (grease) is added. It was found that if the size softener contained even traces of unsaponifiable mineral grease, then "bubbly doping" was the inevitable consequence. The result was that pure, saponifiable greases, such as tallow, palm oil, or Japan wax, had to be specified as size softeners, and afterwards no further trouble arose on this score.

Since there has been little precise work upon india-rubber, its use upon aircraft has necessitated a considerable amount of investigatory work and close inspection in order to ensure the absolute dependability of the finished product.

This has been especially the case with "gasoline-resisting hose"—an india-rubber tubing with canvas insertion, short lengths of which are used to connect up the gasoline, oil, and water systems of an airplane engine. These rubber connections have proved to be essential to obtain unions which do not fracture under the sustained vibrations to which they are subjected.

Since gasoline dissolves ordinary india-rubber, causing it to swell and become "cheesy," thus choking the bore of the gasoline pipe, considerable research had to be undertaken to find a mixture and the degree of vulcanization necessary to remedy this fault. The specification which was ultimately drafted laid down that the sample shall satisfactorily withstand one hour in boiling gasoline followed by 23 hours in the cooling gasoline.

A very vital and more recent employment of rubber is in the construction of "self-sealing" or bullet-proof gasoline tanks. The fuel was the source of the great majority of the fires on airplanes during the war, and these self-sealing tanks have proved of the greatest value in effectually stopping accidents on this score. The tanks are made of thin sheet metal with an external coating of rubber about ¼ in. thick. On being struck by a bullet which pierces both the rubber and metal walls of the tank, the rubber springs back into place and thus closes the aperture. The quality of the rubber cover of a bullet-proof tank must be the opposite of that employed for gasoline-resisting hose, in that the rubber on the bullet-proof tank must tend to swell in gasoline since such a property would assist the sealing process after a bad or jagged penetration.

From the foregoing it will be seen that the present-day designer has a choice of materials, the range and quality of which were undreamt of by his predecessor of a few years ago.

A suitable and reliable material exists for every specific part, and by a wise selection of such material the designer can ensure that his machine will be safe from the point of view of material specified in his designs. Furthermore, present-day methods of manufacture place him in a position to attain such safety at reasonable cost. This is the outcome of the fact that the development of the characteristics of aircraft from a safety point of view has progressed possibly at a faster rate than any of the others. Research work carried out at the R. A. E., particularly in regard to establishing the loads which may be encountered in flying under all conditions of maneuver, has given the designer some concrete evidence on which to base his calculations for determining the sizes of the various structural members. The invention of an instrument known as the "Lindemann Accelerometer" to determine such loading has been satisfactorily accomplished, and many tests have been carried out with this instrument on a large variety of aircraft subjected to all sorts of acrobatic maneuvers.

The development of stability requirements has also reached a stage where one can arrive at the degree of compromise between stability and maneuver required, and from data now available the behavior of an aircraft can be assumed even before its first flight.

Improvements in Detail Design

In designing the various details of the structure in the earlier days it was customary to resort to the best of everything available in the form of material or labor for producing the parts in question. This stage is now past, as it has been found possible that consideration of manufacture allows such parts to be produced very easily and at less cost without in any way affecting the strength, and consequently the safety, of the part.

Any design which, while incorporating satisfactory material, allows of ease in construction, assists in maintaining safety, for ease in construction is likely to result in satisfactory construction. In this connection a few points may be touched upon, the first of which is welding.

It is impossible to state definitely from the usual visual examination that any welded joint is reliable. The only sure method of proving such a joint is a destruction test such as cutting through the weld. It follows that this method could not be applied to the actual fittings which have to be used in an airplane. Further, the material of the weld is only very mild cast steel and cannot have the structure and strength of worked material. It was therefore decided to forbid welding in any part of a fitting subject to tensile or bending loads. Even where welding is permitted careful heat treatment is subsequently given to the fitting in order to refine the structure of the surrounding metal which will have been coarsened and embrittled by exposure to the high temperature of welding.

Laminated construction has been largely adopted with resultant improvement in constructional method. Wiring plates were formerly required to be of heavy gauge metal; they are now usually made from two or more thicknesses of lighter gauge, brazed or soft-soldered together, which considerably reduces any danger of failing through internal defects in the steel. Further, where lugs are required to be bent to suit the lead of a wire or cable, the component plates are bent separately before fixing together, thus obviating the severe local straining at the bend which is bound to occur in a single heavy plate. Incidentally, all bends in sheet metal are now radiused and failure at these points due to local strain occasioned by the use of sharp-cornered bending blocks, is now non-existent.

Laminated construction has been extended to wood parts, and curved members are now built up from thin strips bent and glued together on a former jig, without the use of steam and the consequent risk of damage.

Laminated spars and struts, although originally introduced to enable small sizes of timber to be built up into serviceable sizes, were found to be as strong as or stronger than solid members. This construction gave opportunity for what amounts to internal inspection of the wood, with the result that the quality of the material throughout a member proved more consistent and enabled a lower grade timber to be used for the same average strength.

Important working parts of airplanes which are covered up while in actual use have been rendered easily accessible for examination purposes by the provision of inspection windows, doors, easily detachable covers, etc. For example, inspection doors are now fitted in planes so that by sliding a panel a control pulley or cable inside the plane can be readily examined or replaced; similarly with a pulley fitted on the outside of a plane, the fairing is arranged so that it can be easily dismantled to expose the pulley. Fuselage coverings are now so arranged as to permit of rapid dismantling where it is necessary to inspect or true up the fuselage.

During the war, additional safety was secured by duplicating the flying wires. This was done in two ways. Firstly, by actually doubling each wire, and secondly, and this is probably more satisfactory, by designing the incidence and drag bracing so that should a flying wire in one truss break, the load is transferred through that bracing to the remaining truss. Extra loads are, of course, thrown on other members of the structure, but these are carefully considered in this connection.

Important control cables are directly duplicated so that failure of one wire does not mean loss of control of the machine.

In the earlier days of flying, the liability of error in manufacture, due to the human element, was considerable. Holes in spars, etc., were drilled with a hand brace and were often out of true or position. Assembly of the parts in many cases resulted in the serious weakening of the member. Further, there was always the risk of errors being concealed, especially where there was a subsequent process of taping or painting. The insistence upon the use of jigs and fixtures has eliminated this trouble.

In the assembly of metal parts to soft wood members such as those of spruce, it is most important that the metal parts are not forced into the surface of the wood, with resultant damage to the fibres. To obviate this, metal fittings are now designed with maximum area at the face of attachment so as to distribute the load as much as possible; hard wood packing pieces are fixed between the soft wood members and the metal fitting, and large washers, or even washer plates conforming to the outline of the fitting are placed under the nuts of the attachment bolts.

Such parts as nuts and bolts, turnbuckles, and rafwire forkends are liable to come adrift when subjected to vibration unless suitable locking devices are employed. Bolts attaching fittings which are not required to be removed are permanently secured by riveting over the end on the nut or even slightly burring. Castellated nuts and split pins are invariably used when the bolt is liable to require removal at any time. Turnbuckles are prevented from unscrewing by means of a soft iron locking wire. Rafwires and tie rods are usually locked by means of lock nuts at each end, but this method can only be satisfactory when extreme care is taken in tightening up the nuts or using a lock nut made from a softer material than that of the screw. Alternative locking devices for cross bracing wires are now available. Another method applicable to duplicate wires is the clamp plate extending over the two wires.

Even though all these safety devices be arranged for in design, there still exists a necessity for daily inspection when the machine is in use. This is dealt with more fully later.

Durability of Engines

From the point of view of durability of engines and component parts, great strides have been made in the past few years.

In this connection it is interesting to note that in pre-war and even in the early war-time engines, the average life before overhaul was comparatively low, that of one of the best stationary engines of the time being approximately 50-60 hrs., and the most reliable rotary engine averaging 15 hr. actual running time before complete overhaul became necessary.

With the tendency in the present-day engines toward obtaining higher power and the consequent necessity to increase the number of cylinders, the difficulties encountered in the production of a reliable engine are proportionally increased. The fact that the running time of some of the modern stationary engines is 200 hr., and upwards, and that of rotary engines is 50 to 70 hr. before complete overhaul becomes necessary in the respective cases, makes it obvious that great improvements in materials and design have been effected.

With the advent of commercial aviation, it becomes necessary to consider the safety point of view above all others, reliability being of paramount importance. In order to secure the highest degree of reliability, it is possible that the low weight power ratios now obtainable will have to be sacrificed to some extent and, even if the power remains the same, the weight may be slightly increased with advantage.

This is not a retrograde step, as with present-day knowledge of materials and thermo dynamics, such an engine for this purpose would probably prove superior to those at present in use. For example, a racing car engine is not the best for a touring car, likewise a touring car engine is not suitable for lorry work. We must therefore apply these principles to commercial aircraft engines. There are indications that the most suitable engine for commercial purposes is one running at a speed which allows the propeller to be driven direct at approximately 1,400 to 1,500 r.p.m., which has ample bearing surfaces, is reasonably economical in oil and fuel, and is of clean and simple design.

Large aeronautical engines are, almost without exception, water-cooled, and the cooling system is an added complication, giving rise to the possibility of many failures, more so, however, in war than under commercial conditions. Air-cooled engines of large power are rapidly coming forward, and the use of such engines will tend, by the elimination of these possible failures, to promote the further safety of commercial flying.

As previously mentioned, the use of the highest grade of light alloy and high tensile steels has become general, and considerable attention has been paid to the manufacture of components from these materials, particularly with regard to stamping, drop forging and heat-treatment. More than ever, the preliminary operations on the raw materials have been studied in their relation to the design of the finished component, and the satisfactory use of forgings in high tensile steels has only been possible by the special attention and investigation which has been given to this subject.

The testing of individual parts during manufacture has allowed of the discovery and elimination of possible causes of failure, which under the usual methods of inspection would not have been discernible in the finished product. Such testing has been responsible for the increased reliability of engine components.

Particular attention is given to pressure tests on rough and machined castings. All oil passages, whether in castings or machined parts, are tested under pressure during and after erection, in order to ensure that no source of trouble may develop during the early life of the engine.

In many early designs a source of great weakness was the permitting of sharp corners at the bottom of key-ways.

Present-day practice overcomes this defect, for in machining the various parts, great attention is paid to the elimination of sharp corners, scratches, undercuts, and sudden changes of section which may tend to develop fatigue fractures by the localizing of stresses.

Special attention is paid to the satisfactory locking of all detachable parts which are subject to vibration or reversals of stress, and much of the improvement made in detail design is due to the satisfactory way in which this has been carried out on parts which were previously considered unimportant.

As a further check on the reliability of engines, the bench tests imposed are of much more strenuous nature than were applied in the past, and methods of testing and the equipment employed have been considerably improved as the result of war-time experience. The use of torque reaction brakes or test stands, fuel meters, etc., enable accurate values to be obtained in regard to hp., and fuel and oil consumption, and any slight variation from the normal is easily detected by these means.

Regarding the installation of the engine and its accessory plant, great steps have been taken toward the elimination of faults in design and workmanship which were a constant source of danger in earlier types of aircraft.

Investigations into the cause of accidents and forced landings have shown that a large number of such accidents were due to some slight defect developing in the engine installation plant, therefore it became necessary to devote greater attention toward overcoming all possible sources of failure. A fear which was continually present in the minds of most pilots and others concerned in flying was the danger from fire caused by inattention to vital details of engine installation which it was customary to consider of minor importance in those early days. This has now been greatly minimized in modern machines by so arranging the inflammable structure that no part is exposed to direct or indirect heat. The carburetor air intakes are now led outside the fuselage or engine nacelle, and backfires or blowbacks are rendered harmless.

The accumulation of loose gasoline is prevented by attaching drain pipes to the lowest points of carburetor inlets and air intake pipes, these drain pipes being led out and away from the fuselage.

Another source of danger arose from the fact that electric leads were frequently run in exposed positions and secured to the longerons and spars by means of metal staples, thus in due course laying bare the wire and so increasing the danger of firing any accumulation of gasoline vapor which might be present. To overcome this it has been laid down in all Service machine contracts and rigorously observed that all electric leads must be run in guard tubes, preferably of a non-metallic character, and must on no account be attached to any part of the machine by metal fixings.

The engine itself has undergone important modifications all tending to decrease danger from fire, and the chief amongst these improvements is to be found in the magneto. Modern magnetos are totally enclosed; any internal sparking therefore cannot set alight any gasoline vapor which may be present. The present design of carburetors also follows this example, most modern carburetors being so enclosed as to eliminate the possibility of gasoline leakage. The location of the engine has also an important bearing on fire risk, and the modern tendency is to mount the engine in an all-metal structure, thus insulating it from the remainder of the machine. This is easily effected in the case of rotary or radial engines having a vertical plane mounting and multi-engined machines with engines mounted in separate nacelles.

With the increasing tendency toward the use of all-metal structures, it is obvious that the work of making single-engine machines fireproof will be considerably decreased. In connection with this it is interesting to note that machines are already in existence, in the construction of which the use of inflammable material has been entirely eliminated.

Several mysterious fires have led to a belief that static electricity has caused discharges between adjacent metal parts of the machine due to differences in potential, thus setting light to gasoline vapor. On small machines this effect is negligible, but on larger machines the presence of parts at different potentials exists under certain circumstances. To neutralize this effect it has become the practice to ensure electrical continuity by wire bonding all parts of the metallic structure. In cases where machines are fitted up with wireless apparatus the receptive capacity of the airplane is increased and aerial wires may be dispensed with.

Improvements in the Gasoline System

A continual source of trouble in the earlier days was due to gasoline pipe failure, this in its turn causing failure and stoppage of the engine and sometimes led to fire due to the gasoline coming in contact with the exhaust flame or spark from the open type of magnetos, etc.

Fracture of pipes was generally due to lack of provision for absorption of vibration. In all modern machines an essential point is the insertion of some form of flexible joint at frequent intervals in the pipe lines, especially at points where pipes enter and leave the engine mountings, fuselages and other fixed components. A largely used form of flexible joint consists of a short length of gasoline-resisting rubber hose connecting the two ends of the pipe. To ensure alignment and relieve the rubber from stress, a barrel-shaped tube or "Olive" is inserted between the slightly bell-mouthed ends of the pipes. The rubber hose is passed over the whole and secured by means of clips at each side of the joint.

A point of extreme importance and one to which insufficient attention was given in the past is that relating to the supply of gasoline. Contributory causes of failure were insufficient pipe area, filter gauzes of too fine a mesh, restricted flow caused by bad bending, air locks due to defective design of pipe lines, and presence of foreign matter in the gasoline system. To obviate these troubles various improvements in design and inspection have been effected. The dimensions of gasoline pipes in modern machines have been materially increased to ensure a minimum flow of 100 per cent in excess of engine consumption at full power. Filter gauzes of restricted area and too fine a mesh are dangerous inasmuch as they so quickly become choked and restrict the gasoline supply. To correct this a standard mesh gauze has now been provided, namely, 120 by 140 per in., and a standard filter is required on all aircraft the dimensions of which ensure an adequate supply of gasoline.

In the early type machines it was invariably the custom for gasoline to be supplied from gravity tanks placed at a sufficient height above the engine to have an adequate head of gasoline ensuring an ample supply to the engine. With the progress made in larger machines it became necessary to keep the gasoline tanks low down, thus some means of raising the gasoline to the engine carburetor became necessary. For this purpose an air pressure system on the tanks was adopted, the pressure in the tanks being supplied by means of a hand pump, and afterwards maintained at a constant pressure by means of either a wind pump fixed to a convenient part of the machine, or a mechanical air pump driven off the engine. This method was effectual while the pressure was maintained but was open to several objections, most important of these being that if from any cause a fracture of any of the pipes occurred, the pressure was immediately lost with the consequent result of cutting off the supply of gasoline from the engine. In a war type machine this point was of vital importance, as a bullet through any pipe or tank immediately placed the machine out of action. With the air pressure system it is also most important to prevent undue pressure on the carburetor, otherwise flooding will result. The usual method adopted to overcome this difficulty was to employ a safety or relief valve in the air pressure system, this being set to blow off at approximately 2½ lb. per sq. in. These safety valves were, in the majority of cases, unreliable in action, and coupled with the fact that air pressure pumps frequently failed, this system is not recommended.

With the advent of multi-engined machines some more reliable method of gasoline distribution became necessary. The system most in vogue at present and which has much to recommend it is to induce the gasoline from the tanks by means of gasoline pumps in lieu of forcing it out as in the air pressure system. In most gasoline systems the gasoline is delivered direct to the carburetors, and any excess of gasoline supplied and not required by the engine is returned back to the tank via an overhead tank of small capacity. The object of this small tank is two-fold, it ensures a constant pressure being maintained at the carburetor, and also in the event of

failure of the pump, the reserve of gasoline in the gravity tank allows the machine to be brought down under its own power, although naturally its radius of action under these conditions is limited to the capacity of the gravity tank.

The gasoline pump, as a rule, is driven by means of a small air propeller, and it is usual to supplement this by a hand gasoline pump in order to provide the initial supply of gasoline for starting and also for use as required in the case of emergencies. Danger of failure to gasoline supply is thus materially reduced, and engine failure through this cause is becoming daily of less frequent occurrence.

There is an interesting method in use on some machines which utilizes the vacuum created in a Venturi tube by the passage of the machine through the air to raise gasoline from the main tank to the gravity tank. A float arrangement maintains the gasoline level in the gravity tank and cuts out the vacuum to prevent gasoline being sucked down the Venturi. When the gasoline level falls to a pre-determined extent the vacuum comes again into action, again filling the gravity tank. A small hand-operated centrifugal pump is provided as a standby.

Great improvements have been made in small accessories, particularly gasoline cocks. Owing to its low viscosity, it is extremely difficult to prevent gasoline leaking, and only the highest class of workmanship is necessary to produce a satisfactory cock. This is realized to such an extent that only three cocks are at present approved for use on Service machines.

Engine Accessibility

A point which received little or no attention in the early machines was the accessibility of the engine and its various components. It will be instantly realized that in order to ensure an engine being constantly in running order it must receive frequent attention, not only to the engine itself, but also the installation.

In early type machines it was of frequent occurrence for magnetos, carburetors, water pumps, filters, etc., to be placed in such positions and built around by cowling to such an extent that an immense amount of time and trouble was necessary in order to examine the parts as or when required. Under these circumstances it will be easily imagined that many parts were left untouched and uninspected for considerable periods.

It will be appreciated that under these conditions the engines suffered to a considerable extent, and engine failure through inattention to small details was prevalent to a great extent. A typical instance of this lack of accessibility can be cited on one machine which was in service during 1916, the engine of which was completely enclosed by a 3-piece metal cowling secured to the machine by 238 screws and nuts.

In order to change the radiator of this machine it was necessary to remove the whole of the cowling, and to obtain access to the carburetor or magnetos, two pieces of cowling had to be removed. In modern machines accessibility is made a strong feature of design, the cowling in most instances being secured by hinge pins, thus enabling the engine to be laid bare within a few seconds. In addition, inspection doors are provided at convenient points, allowing access to essential parts without the necessity of dismantling the cowling. A very good instance where accessibility is carefully considered is to be found in a recently constructed machine. This airplane is fitted with a large radial engine, and the mounting plate is so arranged that it hinges vertically on one side and can be swung around so as to expose the whole of the rear of the engine with all its accessories.

Concerning the accessibility of all the various engine components, regulations have now been drawn up and are required to be rigorously observed in all aircraft contracts. These regulations provide for the accessibility—for inspection and removal—of the magneto and its fittings, carburetor, filters, oil and water pumps, and all rubber connections.

In the foregoing I have endeavored to trace, albeit briefly and imperfectly, the advance which has been made in all stages of aircraft work, from the raw material up to the finished product. In every case these steps have been primarily in the direction of the attainment of greater safety and reliability, and it is the cumulative effect of these revolutionary improvements to which the present-day aircraft owes its inherent safety. But even when the aircraft is complete and presumably ready to take the air as a flying unit, there still remains an important head under which safety is to be considered, namely, Operations.

Safety in Operation

Under this head we must first consider the fact that although the machine is complete, assembly and erection are not all. Although the machine has reached the stage where a certificate of airworthiness may be granted, conveying to the general public that the design of aircraft, as regards strength, stability, etc., is approved, and also that the materials, processes and workmanship employed in the construction of such aircraft have been inspected to the satisfaction of an approved authority; the effective functioning of all its parts has yet to be gone into technically.

The gasoline must flow to the engine, the oil must reach the engine, and the controls operate freely and correctly. It is here that the designer has in the past been liable to stumble, he has not fully realized the necessity for close relationship between the engine, tank, controls, and the hundred-and-one other fittings which go to make up a flying machine.

The tanks, pipe lines, ignition, etc., of the modern airplane are undoubtedly complicated, often unnecessarily so, and as already stated a large percentage of accidents may be traced to faulty design of the installation, insufficient knowledge of the methods necessary for erection and insufficient care in ascertaining that the various parts function correctly. The whole of the installation requires daily attention and daily watching, and this can only be done by a man specialized in the art. Under civil operations such a man is known as a ground engineer. Under present conditions, after a machine has received its certificate of airworthiness, the responsibility for its general maintenance and repair, determination of periods between overhauls, correct tuning-up, testing, and generally ascertaining that the machine is safe for flying at any and every time, lies with the ground engineer, and it will thus be seen that his work is of the highest importance.

By regulations made under the Air Navigation Act, the ground engineer is required to be duly certified by a competent authority appointed by the Air Ministry, and must undergo an examination to qualify for a license. Such examination is carried out by representatives of the Director of Aircraft Inspection. The standard set is a high one, and rightly so. These licenses are divided into two categories—one for the inspection of airplanes and for engines for daily flight, and one for the overhaul, repair and inspection after overhaul of airplane and for engine, and of the two types, the man who must look after the overhaul and repair, to my mind, requires the higher skill and experience. He has a difficult task, he must first of all decide how often he should pull out his engine, how often make a complete overhaul of the machine, and, when everything is stripped, decide what should be replaced, and that replacements are correct in accordance with drawings and specifications of required material. If the machine has crashed he must decide as to what extent the original components may safely be used again. The man who pays the bill may not be very encouraging with regard to replacements and renewals, therefore the ground engineer must have a good knowledge of costs to enable him to make his recommendations in such a way that the machine is restored safe for flight with the minimum cost.

There is a loophole for danger to creep in when repairs are conducted away from the aircraft manufacturer. As a general rule, the material required for repairs is not at hand, or if available may be unsuitable. It may be that those responsible for repairs do not know of what the parts are made, and there is certainly a danger of spare parts, which have not been manufactured to specification requirements, being used. I would recommend every manufacturer of a machine, and especially of the engine, to make it a condition of sale that spare parts are obtained from him. Any user would be well advised to pay the greatest possible attention to this point and to encourage his ground engineer to safeguard himself in every possible way.

I consider the status of the ground engineer should be universally regarded as a high one, and that it must be maintained as such, for there is no doubt that a ground engineer with a good reputation spells safety, not only from the point of view that a machine passed by him is safe, but also from the confidence he unconsciously inspires in the pilot. The very

highest tribute is due to these ground engineers who are responsible for the preparation of the machines which have been, and are still making daily trips between London and Paris.

Regarding suitable personnel for the position, I am of the opinion that the average pilot who received his training during the war will not, as a rule, make a suitable ground engineer, because, firstly, he is not generally an engineer, and, secondly, he has been trained in flying for fighting purposes rather than in the mechanical details of his machine. Again, the purely workshop engineer has not had the experience of the aerodrome to enable him, so to speak to feel the pulse of the machine, for this is an engineering art only to be learnt on the aerodrome. It follows then, that the ideal ground engineer is the man with workshop experience and a good knowledge of materials and process combined with an aerodrome experience which enables him intuitively to place his hand upon the source of any trouble which may develop.

A system of supervision is in force whereby the work of the ground engineer is periodically supervised by duly authorised representatives of the Director of Aircraft Inspection.

Coming to the concluding point of operations, reasonably good taking-off and landing grounds must be provided. Efficient wireless installation and signalling systems either by flares or searchlights should all be maintained at a high standard. An example of the progress in methods of communication may be found at Hounslow Aerodrome, where the Aircraft Transport and Travel Company have fitted a wireless telephony installation by means of which direct communication may be maintained between aerodromes and with their pilots throughout the journey between London and Paris. Proposals have already been considered for the installation of an aerial lighthouse system on the London to Paris route, and an experimental lighthouse has been erected at Hounslow. There is no doubt that much can be done to promote safety in this direction. Wireless liaison between aerodromes and countries, by which weather reports may be exchanged, provision for emergency landing grounds, marking out of routes, etc., all go to promote safety, and it is in this direction that Government aid would appear to be of most benefit to the progress of the industry.

Aluminum Alloys *

By Zay Jeffries, M. S. A. E.

Research Director, Aluminum Manufacturers, Inc.

Iron ranks first, of all the metals. It is unthinkable that any other metal will even approach iron or steel in importance in our generation. Copper, lead and zinc come fairly close together in tonnage, but we think of copper as being next in importance because it is higher-priced. Tin ranks next, with slightly greater tonnage than aluminum, and aluminum is fifth of the non-ferrous metals.

Metallography of Aluminum Alloys

When copper is added to aluminum the compound $CuAl_2$ is formed, as shown in Fig 1. This dissolves in solid aluminum up to about 4 per cent copper at 500 deg. cent. (932 deg. fahr.), and the solubility decreases to less than 2 per cent at room temperature. Above about 4 per cent of copper, a eutectic forms between $CuAl_2$ and aluminum-$CuAl_2$ solid solution. The tendency for the $CuAl_2$ to separate out in the free state is very marked, that is, the solid solution seems to be easily divorced from it. The variable solubility of $CuAl_2$ with change in temperature makes it possible to change the properties of the aluminum-copper alloys by heat treatment.

Zinc forms the compound Zn_2Al_3 which is soluble in aluminum up to 40 per cent of zinc. Fig. 2 is a micrograph at 250 diameters of a cast alloy containing about 85 per cent of aluminum and 15 per cent of zinc.

Magnesium forms Mg_4Al_3 which is soluble in solid aluminum up to about 13 per cent of magnesium at the eutectic temperature. The solubility of the compound decreases with the temperature to about 5 per cent of magnesium at 300 deg. cent. (572 deg. fahr.), and probably to still lower values at atmospheric temperatures. Under equilibrium conditions a eutectic is formed between the saturated solid solution and the compound Mg_4Al_3 when the magnesium content exceeds 13 per cent. Under normal conditions of cooling in sand, the eutectic is formed as a network around the grains when the magnesium content is over 6 per cent. Magnesium also combines with the silicon present in commercial aluminum, forming the compounds Mg_2Si. This compound is very brittle and renders the metal containing it in excessively brittle. (See Fig. 3.)

Iron, manganese and nickel, form $FeAl_3$, $MnAl_3$ and $NiAl_3$ respectively. Fig. 4 shows the structure obtained by adding 3½ per cent of iron. These constituents are very slightly soluble in solid aluminum and separate out in the form of needles when more than 0.5 per cent of any of the elements is present. The $FeAl_3$ needles have a strengthening effect on most aluminum castings by virtue of the fact that the normal eutectic network is made less continuous. As the fracture in nearly all aluminum castings takes place in the eutectic network, the $FeAl_3$ needles make the path of rupture greater and hence increase the breaking load. By increasing the breaking load more deformation is forced upon the more ductile excess material, than producing a higher elongation. Iron in amounts up to 1.5 to 2 per cent may therefore be quite beneficial in aluminum castings.

Fig. 5 shows the effect of adding 2.75 per cent of copper, 7 to 8 per cent of zinc and about 1½ per cent of iron. The iron needles form in various places. $CuAl_2$ is also formed and 7 to 8 per cent of zinc is present without forming a complete network. This alloy is both strong and ductile, having an average tensile strength of 27,000 lb. per sq. in. and an elongation of 4.5 per cent when cast in green sand in the form of a testbar about 0.5 in. in diameter.

The Phenomena of Growth and Ageing

Some queer things happen in these aluminum alloys about which we knew very little a few years ago, and about which we know comparatively little now. But we know much more than we did a few years ago. For example, referring to Fig. 1, no matter how this alloy is cooled in ordinary methods of production, upon reheating to a temperature around 300 deg. cent. (572 deg. fahr.), a permanent change of volume takes place. This permanent change of volume is found in all the commercial alloys of aluminum which have been studied. It differs somewhat in magnitude, but it is present in every one. The change in volume can be made permanent at the room temperature so that the casting can never grow any more.

The first place where this came to my attention was in connection with racing-car pistons, where the temperature had been very high and the pistons had actually increased in diameter. Like a great many other things it was at first considered skeptically, but there is absolutely no question about it now. It is not an important factor in the ordinary water-cooled engine, because the temperature is seldom high enough to cause growth, except perhaps in the head, where the clearance is ample to take care of the growth. But in air-cooled cylinders and in racing engines, there is no question that the pistons are susceptible to a certain amount of growth.

Other things are encountered in aluminum alloys that have been happening to all the alloys used in motor cars since the industry began, but which we did not know much about until recently. When aluminum alloys cool to room temperature, they keep on changing in physical properties at that temperature. The old standard No. 12 alloy, for example, when cast in sand, has a certain tensile strength and elongation, but 24 hr. after casting it has different properties. Its strength has increased slightly, and its ductility has decreased slightly. After a few months the change is still more in the same direction. In one of the more ductile alloys, a reduction in elongation from 8 per cent in the freshly-cast alloy to 5 per cent after a month's ageing is sometimes found, while the tensile strength and elastic limit increase.

All of the castings that have been used in the last fifteen years have been undergoing this change, which is nearly complete in thirty days at ordinary room temperature. No serious disadvantages have arisen, so that the fact that we know now that these changes take place should not cause alarm. It may lead a little later to a more intelligent use of material in places where these changes might possibly be accompanied by a slight change in shape, or even a change in volume.

Effect of Alloying on Physical Properties

The unique effect of zinc in increasing tensile strength is indicated in Fig. 6. Starting with pure cast aluminum with a tensile strength of 13,000 lb. per sq. in., copper is added in various amounts, as shown. The tensile strength increases according to the curve shown in Fig. 6. Nickel forms the compound $NiAl_3$, which has properties somewhat like iron, but it is more soluble in aluminum than $FeAl_3$. Iron reaches a maximum tensile strength at 2.5 per cent, whereas nickel shows a maximum at about 5 per cent.

The addition of zinc presents an entirely different type of curve from those of the other elements considered, because it forms a different structure. The tensile strength increases gradually up to 12 per cent of zinc as shown in Fig. 6, and, although not shown on the curve, the strength increases up to 35 per cent of zinc. We have made a set of cast test-bars with an aluminum-zinc alloy containing a little iron, which averaged over 50,000 lb. per sq. in. tensile strength. We do not consider this a good alloy because it is brittle and the specific gravity is over 3.3, whereas all the other alloys mentioned are under 3.0. A high zinc alloy of this kind is in general unsuitable for engineering uses.

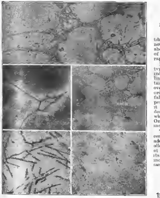


Fig. 1—Copper
Fig. 2—Zinc   Fig. 3—Magnesium-Silicon
Fig. 4—Iron   Fig. 5—Zinc Copper

PHOTOMICROGRAPHS OF VARIOUS ALUMINUM ALLOYS MAGNIFIED TO 250 DIAMETERS

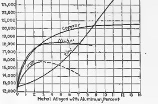


FIG. 6. EFFECT OF VARIOUS ELEMENTS ON THE TENSILE STRENGTH OF ALUMINUM

When the effect of these same elements on ductility is measured by the percentage of elongation, zinc is again seen to be in a class by itself. It is evident that copper reduces ductility faster than any other element. The addition of iron is not very practical above 2 per cent, while nickel produces about the same result as copper and costs more. The addition of zinc does not decrease the ductility of the castings as rapidly as any of the other elements.

Fig. 8 represents the effect of temperature on two different types of alloy. The tests were made at the temperature indicated. Consider the alloy represented by the dotted lines. This is a strong alloy known as Lynite 145. It contains 2.75 per cent of copper, 7 to 8 per cent of zinc and over 1 per cent of iron. It has a high tensile strength at ordinary temperature, say a little above 0 deg. cent. (32 deg. fahr.). In this particular sample it was about 28,000 lb. per sq. in. and the elongation was about 8 per cent. In testing it with a rise in temperature it is found that its strength decreases regularly up to 300 deg. cent. (572 deg. fahr.), at which temperature it is slightly under 9500 lb. per sq. in. On the other hand, its elongation increases rapidly with an increase in temperature.

The alloy represented by the full line contains about 12 per cent of copper and about 0.75 per cent of manganese. The addition of the manganese has the function of making this alloy stronger at temperatures above those of the room than at room temperature. The elongation slightly increases, but its change is not marked. The tensile strength, however, increases up to 200 deg. cent. (392 deg. fahr.) and we have samples that increase up to 250 deg. cent. (482 deg. fahr.)

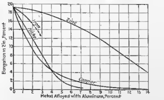


FIG. 7. EFFECT OF DIFFERENT ELEMENTS ON THE ELONGATION OF ALUMINUM

* Paper read before the Detroit Section, S.A.E.

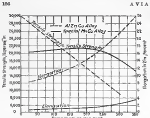


FIG. 8 EFFECT OF TEMPERATURE ON THE STRENGTH AND ELONGATION OF TWO ALUMINUM-BASE ALLOYS

At 300 deg cent. (572 deg fahr.) one alloy has a tensile strength of 9500 lb per sq in, and the other alloy more than 18,000 lb per sq in The second alloy is twice as strong as the first at this temperature with sufficient ductility, over 2 per cent, to make this advantage a decided factor in its use This alloy is used to some extent at present in experimental cylinders, and also in cylinder-heads and other parts requiring considerable strength at the higher temperatures.

Comparison with Other Metals

A comparison of aluminum with machine steel is interesting, especially in connection with fatigue values. The modulus of elasticity of machine steel is 30,000,000, which is indicated by the slope of the straight-line portion of the curve in Fig 9 An aluminum alloy containing about 4 per cent of copper, 0.5 per cent of magnesium and 0.5 per cent of manganese, has a straightline graph up to about 20,000 lb per sq in, but the slope is quite different from that of the steel stress-strain line The modulus of elasticity of aluminum is 10,000,000 lb. per sq in., whereas machine steel breaks sharply after it reaches its elastic limit or yield point, and a slight increase in load produces a large permanent set. The forged aluminum, after passing its proportional limit, continues in such a manner that a slight permanent set produces a marked increase in the elastic limit, so that it has the ability to check its deformation after passing the yield point.

Cast aluminum alloys have the same modulus of elasticity as the forged alloys, but the proportional limit is usually lower, say 7500 lb. per sq. in, as opposed to 22,000 lb per sq. in. in the forging But after the cast aluminum reaches its true proportional limit, the curve rises nearly straight for some distance, so that it requires a large increase in load to produce a slight permanent deformation The whole point of the matter is that the steel takes a large deformation for a slight increase in load, after the yield point; while both cast and forged aluminum stand a large increase in load for a slight increase in deformation, above the yield point

So far as fatigue values are concerned in the White-Souther tests, something quite unique is noted. A stress-strain diagram of an aluminum casting like the one already mentioned, stressed to 14,000 lb per sq in, which is well above its proportional limit, will break after about 500,000 reversals. Stress it to 8500 lb per sq in. and it will require 16,000,000 reversals to break it But mild steel, having a tensile strength of 65,000 lb per sq. in., an elongation of 30 per cent and a yield point of 30,000 lb. per sq in, will break at 16,000,000 reversals at a load of only 12,000 lb per sq in Cold-working does not help it. These values are reported by Moore and Putnam, of the University of Illinois, in a report of the National Research Council investigation. The question to be explained is why mild steel will break at say 12,000 lb. per sq in., which is below the proportional limit, after 16,-000,000 reversals, either annealed or cold worked, and why aluminum will stand the same amount, a little above its proportional limit, that is, 16,000,000 reversals. My opinion of this at present, as far as aluminum is concerned is that the main constituents themselves are well below their fatigue resistance stress, and that the measured proportional limit represents the premature breaking of some of the unfavorably situated brittle constituents in the alloy.

I will mention one generality, however, in connection with steel, that seems to represent the consensus of opinion after a considerable amount of experimentation in both England and this country, although it is still awaiting further confirmation, like most of our fatigue data. With a given steel, there are only two ways to increase the fatigue resistance, (a) to reduce its grain size by working and low-temperature annealing, or by grain refinement, and (b) by heat-treatment. Cold-working does not seem to increase the ability of a given piece of steel to withstand long-sustained fatigue.

Forging Alloys

The forging alloys are mixed like all other aluminum alloys and poured into ingot form, the ingots are either rolled or pressed out into billets, which are then forged into various shapes. We have found that the forgings give very uniform results. Greater uniformity is secured than was anticipated. Heat-treatment is very beneficial The untreated alloy may have a tensile strength of about 40,000 lb. per sq. in. and an elongation of about 15 per cent. Properly heat-treated, the alloy will have a tensile strength of about 55,000 lb. per sq. in, an elongation of 20 per cent and an elastic limit of 20,000 lb, or more, per sq. in. Thus we have a material of about one-third the specific gravity of steel, with the properties of mild steel We know that, section for section, this does not compare favorably with the alloy steels in their heat-treated condition

The stiffness or rigidity of a material is a very important factor in many engineering products. Stiffness depends directly upon the modulus of elasticity of a material, and varies as the cube of the thickness of any particular section. Here again aluminum alloys possess advantages as structural members. Making a rough calculation for an aluminum plate of the same weight as a steel plate, the aluminum plate would be about three times as thick. Having one-third the modulus of elasticity, its stiffness would be only one-third insofar as this factor enters, but, being three times as thick as the steel plate, with the same modulus of elasticity, it would be twenty-seven times more rigid, so that we divide the 27 by 3 and get 9 to 1 in favor of aluminum, weight for weight. Actually, for the alloys which are slightly heavier than aluminum, that factor comes out between 7½ and 8 to 1, instead of 9 to 1 If figured the other way, with one-half the weight in plate section, the aluminum would be equally as stiff as steel. This factor is quite important in connection with design for rigidity Another point, perhaps quite obvious, is that rigidity is in general an indication of stress. Absence of rigidity means deformation, usually elastic deformation, it is true, but the stress is directly proportional to the deformation. Consequently, if the elastic deformation is decreased, the stress also is decreased

Aluminum forgings seem to have applications for different

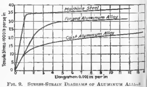


FIG. 9. STRESS-STRAIN DIAGRAMS OF ALUMINUM ALLOYS AND STEELS

purposes due to different requirements. One factor is lightness. Where lightness of reciprocating parts is desired, aluminum connecting-rods would perhaps be valuable chiefly because of this factor At the same time, forged aluminum seems to be a very good bearing material against hard steel, and possibly against medium-hard steel. Accordingly, two advantages can be gained by using aluminum connecting-rods, as a bearing and to decrease weight Moreover, if the aluminum bears directly on the steel, ideal conditions for cooling the bearing result, as aluminum has very high heat conductivity, it should conduct the heat away from the bearings very rapidly.

Another important advantage aluminum alloys have, in certain cases, is absence of corrosion They do not rust like iron. It is true that a coating or oxide forms on the surface of aluminum, but all of the salts of aluminum are white, which is the reason that the oxide of aluminum is inconspicuous. This is true of zinc also. Zinc oxide is white, consequently, when we galvanize a piece of iron, a coating of zinc oxide forms on the outside and we do not think of it as rusting at all In its way the zinc is rusted; but the rust is white or colorless. Even though all aluminum products have aluminum oxide on the outside, the oxide is colorless and also thin.

I will mention briefly some other characteristics of aluminum. One is the coefficient of expansion. In the ordinary timing-gear system the gears might be rigidly attached to one aluminum casting As aluminum expands about twice as much as iron per degree, it might be found that the iron gears had too great a clearance when the engine is warm. Aluminum gears, or even one aluminum gear, would cut down that clearance, because aluminum has a greater coefficient of expansion Another characteristic of any of its alloys which I know anything about is that aluminum as a metal seems to be a poor sound transmitter It does not ring like steel and does not transmit sound and vibration nearly as well as any of the iron products.

Power Required to Drive Aeronautic Engine Magnetos and Generators

Prepared by Engineering Division, Air Service

Object of Test

The object of this test was to determine the power required to drive various types of aviation engine magnetos and generators

Conclusions

It was found that the power required to drive aviation-engine magnetos was too small a quantity to be measured with the equipment available

The power absorbed in driving the Liberty generator ranged from 0 07 hp at 1,800 r p m when delivering a current of 1 ampere, to 0 19 horsepower at 3,300 r p m. when delivering a current of 4 amperes

Method of Conducting Test

A Bosch type ZH-6 magneto was connected to a 5-horsepower electric cradle dynamometer A set of six spark gaps, adjusted to one-fourth inch, was connected in series with the magneto to constitute the operating load The magneto was then driven at speeds ranging from 1,800 to 3,300 r p m in increments of 150 r.p.m., to correspond with the magneto speeds on a 6-cylinder engine operating at 1,200 to 2,200 r p m. The torque required to drive the magneto was noted.

The Bosch magneto was replaced by a Dixie, type 1,200 magneto, and a similar test was made under the same conditions In this case the load consisted of 12 gaps instead of 6

The Liberty generator was then connected to the dynamometer A Delco voltage regulator, a slide-wire resistance, and an ammeter were connected in series with the generator, and a voltmeter across the circuit The generator was driven at speeds ranging from 1,800 to 3,300 r.p.m., corresponding to engine speeds of 1,200 to 2,200 r p m The load was varied by means of the slide-wire resistance to obtain currents of 1, 2, 3, and 4 amperes at each speed. The torque required to drive the generator and the electrical output were recorded

Results

The power required to drive the various makes of magnetos is not tabulated, since the torque was too small to measure. The results of the test on the generator are tabulated below

Observations during Test

The torque reaction of the dynamometer while driving the magnetos was too small to register on a sensitive pendulum-type scale The torque arm would remain stationary when removed from the torque reaction platform.

Analyses of Results

The power required to drive the two magnetos tested, the Bosch ZH 6 and the Dixie 1,200, both of which are representative of the best aviation engine practice, is too small to measure with the available equipment The torque reaction, as was indicated by the behavior of the torque arm noted under "Observations during test," was evidently less than the slight friction in the dynamometer trunnions.

The maximum power required to drive the Liberty generator did not exceed 0 2 hp, an insignificant amount compared with the total horsepower of any aviation engine. This power is much less than the power absorbed by water and oil pumps.

POWER REQUIRED TO DRIVE THE LIBERTY GENERATOR

Speed (R P M)		1-ampere load			2 ampere load			3-ampere load			4-ampere load		
Generator	Engine	Voltage	Torque (Lb ft)	Horse-power	Voltage	Torque (Lb ft.)	Horse-power	Voltage	Torque (Lb. ft)	Horse-power	Voltage	Torque (Lb ft)	Horse-power
1,800	1,200	8.8	0.21	0.07	8.5	0.24	0.08	9.5	0.27	0.09	8.5	0.22	0.11
1,950	1,300	8.8	.20	.07	8.7	.24	.09	9.7	.27	.10	8.7	.32	.12
2,100	1,400	9.0	.17	.07	8.8	.22	.09	9.9	.26	.10	8.9	.31	.12
2,250	1,500	9.0	.20	.09	8.8	.22	.08	9.9	.26	.11	8.8	.30	.13
2,400	1,600	8.7	.19	.09	8.7	.22	.10	8.7	.27	.12	8.7	.31	.14
2,550	1,700	8.9	.20	.10	8.9	.29	.11	8.7	.28	.14	9.7	.32	.19
2,700	1,800	8.0	.20	.10	9.0	.24	.10	9.0	.27	.14	9.0	.31	.18
2,850	1,900	9.2	.18	.10	9.1	.22	.12	9.0	.26	.14	9.0	.31	.17
3,000	2,000	9.9	.19	.11	9.1	.28	.13	9.0	.25	.14	9.0	.30	.17
3,150	2,100	9.2	.19	.11	9.1	.28	.14	9.1	.26	.16	9.0	.30	.19
3,300	2,200	9.7	.19	.11	9.6	.29	.14	9.2	.27	.17	9.1	.31	.19

Automotive Engineering Standardization and Progress *

By Coker F. Clarkson

General Manager, Society of Automotive Engineers

Standardization is the codification of the best consensus of opinion as to what should be specified for those items of materials and dimensions which it is clear can be reduced advantageously to common practice. The purpose is, of course, to improve the conditions of manufacture and operation. The draftsman's time is saved and made more efficient. There is established a very helpful *esprit de corps* as to what can and should be done in the way of standardization. The stocking of materials and many component parts of sub-assemblies becomes possible, time being again saved. The product is improved in quality both as a whole and in detail. Price always tends to become relatively less. The user can maintain the apparatus he has bought more economically as to time and in a pecuniary way. He gains increased knowledge of and confidence in the manufacturer's product by finding therein detail features of construction which are generally known and accepted as good. This is akin to one of the most potent principles of advertising, a feeling of plausibility and propriety is engendered through the effect of general publicity. Common knowledge of this sort is beneficial in all effective commercial operations.

One troublesome misconception of the standards we are discussing is that they are mandatory. Another is that they are manifestos of finality like standards of weight or measure. An automotive engineering standard is a thing that is considered, by men well qualified to judge, good or best for the great bulk of the manufacture in our field, in order to facilitate quantity production in the way I have indicated. The Society of Automotive Engineers has no way of enforcing the use of its standards except insofar as their merit is weighty. This is as it should be, and for a like reason the S A E standards work has been successful. It has been demonstrated over a period of years that most of the standards can be reduced to practice by the great majority of manufacturers with marked benefit to themselves, as well as their customers, in fact, in all cases where the production is not really special inherently, or on account of large substantially identical previous production not incorporating the currently desirable standards. The latter condition is almost inevitably a matter of the relative importance of the past and the future to the manufacturer.

S. A. E. Standards Have Commercial Value

The Society of Automotive Engineers is not commercial in the sense that it can enforce its standards in an arbitrary way. It is commercial in the sense that its standards are of commercial value. The Society can conduct its activities on a somewhat broader and less partisan basis than a commercial organization can. A commercial organization of manufacturers, proceeding as such, without giving effect to engineering questions as such, cannot, on account of sales competitive reasons, get as good results in the formulation of engineering standards as an organization like the S A E can. In more than one instance the Society has established standards that have gone into general practice, after the representatives of the manufacturers directly concerned working together, or failing to work together, had been unable to establish them.

Standards should, of course, be canceled or revised when necessary. They should not obviously be promulgated originally unless there is sufficient evidence to assure their holding good for a properly long period of time. But the whole system should be conducted flexibly and not inflexibly.

Fallacious Arguments Against Standards

The more or less chronic stock argument against standardization is that it impedes individual and engineering progress. This is the sort of argument that is legion and perennial in almost every field of endeavor. I believe that no fair minded man would say that standardization had impeded the progress of the automobile industry. There is every evidence that it has been one of the main reasons for the quantity production in this field, facilitating purchase of materials, improving quality and decreasing cost of maintenance. Quantity production is clearly not possible without a great degree of standardization of some kind, and the standardization the S A E has fostered has surely been most advantageous to the great majority of manufacturers and users in the automotive field. There is a very material saving in the manufacturing cost per car. Screws, taps, dies, spark-plugs, steels and many other materials and parts can be bought at lower prices and for better delivery. The producing companies have saved a great deal of money in lowered materials costs and in lessened production complications. There is no doubt that the standards and recommended practices of the Society of Automotive Engineers have been of incalculable benefit to the automotive industry at large. The cost to the consumer of standard gages has been reduced greatly, compared to what it was when gages were made specially to meet customers' requirements. It is stated that ninety-five per cent of the lock-washers used in automobile fabrication and operation are S A E standard. These are merely examples of a widespread condition as to S A E standards and recommended practices.

A fundamental maxim of the S A E has always been to not endorse or condemn any proprietary article, nor to endeavor to standardize any practice that would impede progress in design. As a class the standards consist of material and mounting-dimension specifications for those things that are essential in the present types of automotive apparatus. Incidentally, it cannot be ignored that the greatest successes have been attained in those automotive fields in which the design of the article produced has been most conventionalized, conspicuously in the automobile field. Much conventionalization is essential in great commercial success with apparatus individually operated by a large number of people in a mechanical way. The most advanced and efficient apparatus cannot necessarily be operated by the average user. The generally prevalent knowledge of the internal-combustion engine is a principal reason for the success of the vast amount of automotive apparatus in use. Intelligent standardization could not check and can only assist such a condition. There is no trade advantage to any single company in not participating in the establishment and practice of rational standardization. Neither is there any advantage in the way of design.

Example of Engineering Progress

In England recently there was designed a simple and inexpensive stationary engine for general purposes, such as dynamo driving and farm work, and at the same time to obtain the very high efficiency which had been attained thitherto only in very costly engines, such as those used for aircraft. It is stated that during a 100-hr. run developing 6 hp., at less than 750 r.p.m. governed speed, the fuel consumption was a little over ½ pt. per hp.-hr., most engines of a similar size consuming ¾ pt. per hp.-hr. It was figured that with this type of engine the money saving per year for fuel would be $65.00 per engine. The engine was single cylinder 4 x 6 in. The oil consumed was 0.012 pt. per hp.-hr. This performance is decidedly an example of appealing engineering progress. The work of the Society of Automotive Engineers in standardization, research and other respects has been and is primarily such as to encourage such development, and not in the least to impede it. The whole purpose of the Society is to bring about improvement in the entire automotive field, increasing the efficiency of engines and power transmitting devices.

The automotive world is one large growing family, both nationally and internationally, and is making every effort to further and make as effective as possible those phases of efficient production of automotive apparatus of great merit, in which the engineering fraternity takes such a deep interest and which are so essential to the Nation industrially and economically. In worldwide trade it is obvious that the maintenance of standardization that will make possible the interchangeability of many materials, parts and accessories, is economically requisite.

* Address at National Gas Engine Association Meeting

The Touring Airplane and the Variable Camber Wing

By J. D. Hill

The demand for better service, or more usable qualities in airplanes is causing considerable thought on the part of many persons now engaged in the aviation industry. It presents to the designer and manufacturer a problem and to the inventor an opportunity or at least a hearing.

If the manufacture and sale of airplanes is to continue as an uninterrupted business something in the way of improving the all round performance of our present machines must be done at once. For even those enthusiasts, who have purchased and used with partial success the kind of machines we have recently had to offer, will soon give up the idea of attempting to use a type of machine that does not fulfill their requirements.

The object of this writing is not the criticism of existing machines. During the past eight years the writer has flown an air distance of some 300,000 miles and is in an excellent position to testify as to the good workmanship and sound construction, as well as the generally good flying qualities of the many types of machines produced by different manufacturers. A fair percentage of this flying has been cross-country work and here the great need for improved performance is most apparent.

As a pilot and salesman, or more correctly, as a missionary worker in aviation, it has been my good fortune, during the last two years, to be continuously in contact with the potential buyer of airplanes of the pleasure or touring type and my opinions have been influenced to a certain extent by this association.

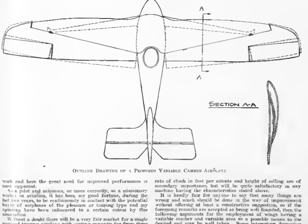
Without a doubt there will be a very fair market for a single motored touring airplane with seating capacity for from three to five or six people, a cruising speed close to 100 m.p.h. and cruising radius ranging upward from 250 miles.

Almost without exception the patrons of our passenger carrying machines name some place to which they would like to fly and when we make a list of their reasonable requests we can picture this machine landing safely wherever man has settled and established a homestead. If the airplane builder will plan and build with this achievement as his objective it can easily be seen that the established landing field will take its logical place as a filling station and repair depot.

Among the desirable characteristics of primary importance for a good touring plane are:

1. Control surfaces easily effective at the lowest flying speed.
2. A quick get-away with the ability to climb at a comparatively steep angle. (Here the need for generous tail controls is apparent in order to quickly bring the ship from the climbing to the gliding position in case of motor failure.)
3. The ability to glide at a steep angle without excessive speed.
4. A reasonably slow landing speed.
5. A very short roll after landing.
6. Control on ground by means of steerable tail skid. The rate of climb in feet per minute and height of ceiling are of secondary importance, but will be quite satisfactory in any machine having the characteristics stated above.

It is hardly fair for anyone to say that many things are wrong and much should be done in the way of improvement without offering at least a constructive suggestion, so if the foregoing remarks are accepted as being well founded, then the following arguments for the employment of wings having a variable camber and variable area as a possible means to the desired end may be well taken. Some interesting discussion of this subject has appeared in recent numbers of AVIATION dealing with the advantages of this style of wing from the



OUTLINE DRAWING OF A PROPOSED VARIABLE CAMBER AIRPLANE

theoretical standpoint and at the same time questioning the possibility of keeping the weight of such a wing within the required limits.

Proposed Design of a New Wing

The purpose of this discussion is to suggest a plan for the building of a variable camber wing having the desired aerodynamic characteristics, and at the same time conforming to the principles of sound engineering, also to point out the necessity for the use of such a wing if the previously mentioned performance requirements are to be fulfilled.

With regard to the question of weight there is little doubt that this wing will be slightly heavier than the same size wing of the usual type. However, on account of its capacity for better performance the overall dimensions of the airplane to which it is fitted will be reduced so there is a possibility of reducing the total weight of the complete machine. The long expected metal wing has recently made its appearance and while metal is not absolutely necessary as the material for this construction, it will serve the purpose very nicely.

In the design submitted herewith, the wing is shown as being composed of two partially overlapping members pivoted together at the apex of an imaginary cone the surface of which determines the degree of curvature of the overlapping surfaces. The forward and upper member is fixed while the second member including the wing tip, trailing edge and under portion of the wing is movable. Its one movement is a rotation to the desired degree about the axis of the said cone all the while preserving its bearing contact with the upper member. Its attachment to the airplane body is by means of bearing pins movable within suitably curved slots in a plate set in the side of the body. A crank and screw mechanism in connection with push and pull rods permit the pilot to shift this movable portion of the wing to any desired position.

Fig. 1 shows the structural simplicity of the design and it will be noted that the movable member includes only those portions of the wing which carry the smallest load per sq. ft. This arrangement makes it possible to simultaneously vary the camber, area, and angle of incidence of the wing by one mechanical movement. The increase in area is effected by increasing the chord length of those sections between the body and the point of pivoted connection between the two wing members.

The question of stability will require attention, but it presents no difficulties since the increase in area is caused by increasing the chord length to the rear with a consequent backward shift of the C.P., while the simultaneous increase in the angle of incidence causes a forward travel of the C.P. If we assume a chord of 4.5 ft., with the C.P. at .38, then increase the chord to 6 ft., whereby the C.P. on account of the change in the angle of incidence may move to some position .28 of chord, the net change in the position of the C.P. with reference to the leading edge will be (4.5 × .38) minus (6 × .28) or .03 ft. in this case a shift forward of about 3/8 in.

Landing Speed

Of the desirable characteristics previously mentioned all are easily incorporated in a machine of the conventional design except the ability to glide at a steep angle with moderate speed, the reasonably slow landing speed, and the very short roll after landing. The term reasonably slow landing speed is used because a machine having sufficient wing area to make its landing speed exceedingly slow is handled with difficulty on the ground in any kind of wind and is liable to serious damage when landing in gusty weather.

Gliding Qualities

The secret of successful cross-country flying is the accurate placing of the ship within the available landing space, and this even with the aid of the very useful side slip is not always easily done. With the old fashioned inefficient pusher type machine the pilot could dive almost vertically down into a field, flatten out and land within a rather small space. This useful characteristic, however, has been lost in the modern machine through the improvements in fineness ratio and increase in speed.

The difficulty of bringing the modern airplane down over high obstacles to a landing in a restricted area is too well known to require any discussion and the overcoming of this difficulty is perhaps the most useful function of the variable camber wing.

Sufficient area, a very deep camber, and a large angle of incidence meet all the requirements for gliding flight with moderate speed at a fairly steep angle. This makes for accuracy of "spotting" the machine at the desired place, for surely it is easier for a pilot to fly to his field and go right down into it rather than to sail around in the usual wide flat circle all the while using his most delicate touch to determine his lowest safe speed. If the variable camber wing served no other purpose than this its use even at a considerable added expense would be amply justified.

Climbing Angle

In climbing out of a small field surrounded by obstacles another useful quality of this wing can be shown. No matter what the rate of climb may be, if the speed is great and the climbing angle small an airplane in this situation will be helpless, for in the few seconds in which it will travel across the field it can not be high enough to clear obstacles. However, if the time allowance is increased and the machine made to fly safely at a reduced speed, the rate of climb may not be changed but the climbing angle can be increased with the result that the machine can get away very easily. The variable camber wing will serve this purpose without detracting in any way from the ship's high speed performance.

The touring plane is going to be put to the most severe flying tests in all kinds of places and if it is to make good it must have the ability, and by this is meant not only the power but also the essential flying qualities—to take off quickly and immediately begin an upward spiral of fairly short radius and while executing this maneuver maintain a fair rate of climbing speed—not flying speed but rate of ascent.

While climbing out of a field in this manner the pilot is, at any instant in case of motor failure, in position to return to his field. It is admitted that the size of the field should determine the radius of this climbing turn; nevertheless a single motored airplane which can not meet this requirement is not safe for general cross-country flying.

Short Roll after Landing

The few machines that have shown good performance in this respect have been of the type that rests heavily on the tail skid, excepting of course some of the one place feather-weight sport planes which are not included in the subject of this discussion. Unless some sort of adjustable castor is provided for the support of the tail, the amount of the ship's weight resting on the tail skid should not be more than one man can handle. Under this condition the amount of drag or braking effect that we can expect from the tail skid is limited. For well known reasons powerful brakes on the wheels are not very desirable, yet some device for bringing an airplane to a quick stop after landing is much needed, and here again the described wing will serve a useful purpose.

With the wings fully extended to secure the desired slow gliding speed the angle of incidence is very large, and when the ship's tail is lowered at the time of landing this angle may increase to a value greater than the critical angle. The resulting increased drift components of the pressure on the wings will serve as an effective brake. This function of a wing having a variable angle of incidence has been mentioned recently by a contributor to AVIATION.

The ability to quickly elevate this wing through the critical angle presents an interesting possibility in the way of forcing a landing at a desired point when gliding close to the ground.

Conclusion

When all the arguments are presented it is evident that the variable camber wing is worthy of the airplane manufacturer's most serious consideration. In view of the fact that the prospective buyer has had his first demonstration, has learned what an airplane can do, what it can not do, and is fast learning what it should be able to do, it is easily seen that the time has arrived for the setting of a new standard of airplane performance.

A well built and good looking touring airplane having the performance characteristics suggested in this discussion should be at once a joy to the maker and its owner. The airplane is now being watched with a critical eye and it is a certainty that demonstrated performance to prove real worth must precede an active market.

Development of German Aircraft Engines*

By Otto Schwager

Translated from *Technische Berichte*, by N. A. C. A.

When war broke out in 1914, the mean power of the aviation engines at the disposal of the German Air Force was 100 to 120 hp. on the ground. The unit weight of these engines, including the water and oil contained in them, was from 1.8 to 2 kg. per hp. The flying efficiency attained with such power was supposed to be more than satisfactory, there being still believed to be absolute safety at an altitude of 1200 to 1500 m. from shots fired on the ground. At this period, aerial combat had not yet been thought of. Even competent authorities scarcely considered it credible that the arming of aircraft would ever be a matter of grave importance.

It soon became evident, however, that ever-increasing demands would be made on the climbing powers of aircraft, in proportion to the progress achieved by the defensive artillery in the technics of firing. Not only was it requisite that climbing efficiency should reach the highest possible point, climbing speed would also have to be raised higher and higher in proportion. With this end in view, increased engine power was the first point taken into consideration. Engines with 150 and 160 hp. on the ground were consequently obtained and there are many cases, even at the present time, in which such engines give results that may be considered to be satisfactory.

Another difficulty then arose. The increasing number of the duties devolving on the pilot led to a corresponding increase in the weight of the load carried by the airplane. We need only mention, for instance, armament consisting of one or more machine-guns with ammunition, bombs and bomb-dropping devices, photographic apparatus and radio, according to the functions of the machine in question, and it was essential that good climbing power and speed should be attained notwithstanding such additional weight. This led to the need for still higher engine powers, and engines with 160, 200, 220 and 260 hp. were produced. The unit of weight of these engines was reduced, in the case of those with 100 and 120 hp., by 1.5 kg. to 1.8 kg. per hp. Flying efficiency did not, however, keep pace with increasing engine power to the extent generally expected, in spite of the effort that was made to construct special aircraft for each particular purpose and to equip such aircraft for that purpose alone, so as to reduce its weight and load to the lowest possible amount.

The ever-increasing demands created by aerial warfare causing the need for a still higher degree of flying efficiency, it became more and more evident that the development of aviation engines must be carried out along new lines, and that increased efficiency alone would not suffice to ensure the desired end, the more so because high powered engines were inconvenient from a flying viewpoint, by reason of their heavy weight and great length, which were unfavorable to the turning facility of aircraft equipped with such engines. Recent efforts in the construction of aviation engines have been developed along two different lines which may be defined as follows: Light-weight Construction and the Adaptation of the Aviation Engine to the Requirements of its Utilization.

Reduction of Engine Speed

In the spring and summer of 1916, the flying efficiency attained through the reduction of the number of revolutions of the propeller used on the engine from 1400 to about 900 r.p.m., by the Mercedes 220 hp. engine was so good that it seemed desirable that all aviation engines should be equipped with similar gear. This idea was justified, as propeller efficiency can be considerably improved by means of such reduction gear. It was most effective on the Mercedes 220 hp. engine with its 8 cyl. placed tandem-wise, but it gave rise to so much difficulty on 6-cyl. engines that the experiments made on the latter, with the gear, had to be given up for more urgent tests.

In spite of this, the Aviation Inspection Department still pushed the use of reduction gear in Aviation engine factories. As early as autumn, 1916, the Department decided upon the utilization of high piston velocity and a high number of revolutions as the standard for geared engines. Constructional work was then zealously started on all sides and the 8 cyl. Vee engine, with power from 180 to 240 hp., was ordered at several factories as the best high-speed engine from the flying standpoint. The unit weight of this engine, including the water and oil carried, was established at 1.25 to 1.35 kg. per hp.,—figures which can be obtained without difficulty, as has been seen in the case of different engines of the same constructional type now ready for quantity production.

The enemy had also been pushing engine development along similar line, at a somewhat earlier period. In the winter of 1916-17, the French utilized their first Vee high-speed engine at the Front, although it had long been known among German aviation experts. The engine in question is the 8-cyl. Hispano-Suiza from which the French, according to accounts given by prisoners, expected marvelous achievements. The early models of this engine were, as yet, not supplied with gear. Their hp. was 140, with 1400 r.p.m., and their unit weight was 1.295 kg. per hp., including water and oil. This engine gives an excellent impression at the first glance, with regard to its construction. It was also so exceptionally highly finished that it attracted a good deal of attention in German aeronautical circles. Many efforts were made to ensure the further production of the engine without other alteration, but this was not done on account of various weak points in its construction, and because German high-speed engines had already been in process of construction before the capture of the first of the French engines.

German Criticism of the Early Hispano

The examination of the above-mentioned engine at the test bench (see Fig. 1) gave remarkable results. To begin with, the engine proved to be a distinctly high speed type, its maximum power being at about 2400 r.p.m. and consequently by no means fully utilized with 1400 r.p.m. and 140 hp. as at the outset. Secondly, however, the engine was found to have considerable constructive shortcomings. Mention need only be made, for instance, of the defective cooling of the exhaust valve, which was burnt up each time at the end of 6 or 8 hours. The construction of the engine was, nevertheless, most instructive and interesting to German manufacturers, and it soon became accessible to them, as it was captured in large numbers. The carburetor, which has already been described in Technical Reports, (Vol. III, No. 4, p. 112) is particularly interesting.

The possibility of constructing high-speed internal combustion engines depends more upon piston velocity and inertia stresses than upon the cross-section of the valve. The piston velocity can easily be carried up to 10 and 15 m/sec., engines having already been constructed successfully with about 17 m/sec. piston velocity, as, for instance, in the case of the French Despujol racing boat engine. The possibility of adopting the largest cross-sectional area of gas-passage is, on the other hand, limited, especially if great importance be attached to the advantageous form of the combustion on account of the high piston velocity, so that the valve must be suspended at the bottom of the chamber. It is desirable that mean gas velocities of 40 to 60 m/sec. should be obtained in the fully opened valves. In such cases, when the inlet pipes are well made and the engine otherwise satisfactorily constructed, a mean effective pressure of 8 to 9.5 may easily be obtained. The power curve of a 6-cyl. Benz aviation engine may be taken as an example (see Fig. 2) with 185 nominal hp. With 1400 r.p.m., this engine produces 197.5 hp. normal efficiency at a mean effective pressure of 8.4 and 1150 r.p.m. with 8.75 as maximum value of the mean effective pressure.

A noticeable feature of this engine is that its unit weight, including water and oil, is only about 1.26 kg./hp. with perfect safety in working, although it is not a so-called high-speed

* Extract from a lecture given at the General Meeting of the Scientific Association for the Technics of Aviation at Hamburg, April 19, 1918.

engine. In contrast to the first high-speed enemy engines produced at the Front, which had no gear at all and a comparatively low number of revolutions, our 8-cyl. high-speed Vee engines were all designed with gear from the beginning. Tests made with the first working models soon showed that the gear itself caused serious difficulties. It was therefore also decided in France that the engine should be constructed without gear for the time being, and foreign high-speed engines still show the question of gear to be by no means satisfactorily solved, as almost every factory licensed to construct the Hispano-Suiza has different dimensions for the spur wheel gear selected for their engines.

The fact of a utilizable high-speed engine needing almost one year and a half for its development in our case is in no respect due to a lower productive capacity on the part of German engine manufacturers, but is the result of the far higher standard of working safety required by us. Not a single foreign engine has so far been able to stand the 60 hours' duration test which must be passed by every German fixed engine before it is considered fit for service at the Front.

Germany's First High-Speed Engine

The first high-speed engine issued in quantity production in Germany was the Benz 195 hp. 8-cyl. high-speed Vee engine with 125 mm. bore, 140 mm. stroke, and 1700 r.p.m. at the crankshaft, producing 225 hp.

With a view to bringing it to technical perfection as soon as possible, the idea of producing it only when equipped with gear has been abandoned, as in the case of the Hispano-Suiza engine, and it has accordingly been mounted without gear, in a limited number, on model airplanes. It is especially suitable for the purpose on account of its high power at 1400 to 1500 r.p.m., as may be seen from the power curve given in Fig. 3.

In the meantime, a rotary gear with a satisfactory safety factor has been successfully constructed for this engine, its maximum efficiency being increased, at the same time, to 260 hp. The construction of this gear somewhat resembles that of the Rolls Royce, which appears to be the best of all the enemy gear. The slightly excessive weight of the structure may therefore be adopted without hesitation in consideration of the simplicity of the spur wheel gearing.

Water and oil included, the engine weighs about 325 kg., which corresponds to 1.25 kg. per hp. Although this is not less than the unit weight of the 200 hp. Hispano Suiza engine with gear, the advantage is still on the side of the Benz engine if we compare it to the total engine plant of a Spad airplane with 200 hp. Hispano Suiza engine, including fuel for 1½ hours, and to the equivalent engine plant of a fighting monoplane, and the comparison is even more favorable to the Benz engine in flights of longer duration, on account of its low consumption of fuel.

Another high-speed German engine of good power and weight, and which has probably also been issued in quantity production by this time, is Korting Bros.' 8-cyl. High-speed Vee engine. Its form is particularly pleasing. With 2150 r.p.m. at the crankshaft, it produces 185 to 195 hp. at the shaft of the spur gear and weighs about 252 kg. with water and oil,—that is, about 1.33 kg. per hp.

According to statements made at the factory, the gear caused no special difficulty, being in that respect unlike other engines in which even simple spur gear could not be made to work perfectly although the demands made upon the teeth were generally less than in the case of foreign engines.

The constructive methods of Daimler and Argus resemble that of the Koerting engine. No reports can as yet be given of their results.

The Adler Works have selected a cylinder system differing from the ordinary method, in the construction of their high-speed engine. In order to obtain a more compact style of construction, two crankshafts are located in one gear box. They rotate in opposite directions, being geared together by toothed wheels, and they work on four cylinders each. The engine works remarkably smoothly and its power output is 225 hp. at the propeller shaft with 2000 to 2100 r.p.m. at the crankshaft. The propeller runs at 1050 to 1150 r.p.m. The locating of both crankshafts in one case entails no actual increase in weight, as the united weights of the crankshafts is only 24 kgs., whereas the Hispano Suiza crankshaft weighs 21 kg. The unit weight of this engine amounts to about 1.24 kg./hp. Gearing difficulties were also originally found in this engine, but they were done away with by a special construction of the toothed wheels.

In addition to the above-named factories, the Oberursel Works are also constructing a high-speed engine designed by Engineer Dr. Becker, Assistant Professor at the Imperial Technical High School in Berlin, which shows some novel details. It differs from previously known models, particularly with regard to the mechanism driving the camshaft, the inauguration of such mechanism would bring the maximum power to the region of 2800 r.p.m. The unit weight of the engine is also a very good feature. With 240 normal hp., at about 2100 to 2200 r.p.m. at the crankshaft, it weighs 260 kg., that is, only 1.08 kg. per hp. This is not due to the utilization of specially high class material, but is attained solely by the disposition and selection of dimensions of the engine. The total stress value is even lower than the usual values. No further details can be given, test reports not being available.

In all these 8-cyl. high-speed engines, the greatest importance is attached to the reduction of their constructional length. For this reason, the magnetos are usually located in front, over the gearbox, with a view to utilizing that space, and economizing space in the rear.

Although the 8-cyl. Vee engine may not be quite equal to the 6-cyl. engine series in equilibrium, the latter series being perfect in that respect, the inertia forces, which chiefly occur in a horizontal plane, caused no noticeable derangement with the dimensions selected. The compensating device which was proposed for the engine was therefore dispensed with for weight-saving reasons, without any detriment to the smooth running of the engine.

For higher powers, the 12 or 10 cyl. Vee engine should certainly be the given method of construction because of the free inertia forces of the 8-cyl. Vee type. Considering the great importance attached to facility in turning airplanes, it will be necessary that the engine should be still further shortened for combat one-seaters; for this reason, the 8 cyl. engine has a successor in the fan engine, which is being experimentally constructed in a three-radii type with 9 cylinders, by Opel of Russelsheim. The next step should be from the fan type to the star engine with a view to obtaining the prefect fixed high-speed engine for single-seater airplanes. This type also gives promise of future developments in respect of higher powers. The star engine also has the great advantage, now that the armor of aircraft is ever on the increase, of being armored with the least weight possible.

The Siemens-Halske Rotary

The endeavor to obtain a high number of revolutions in connection with gearing has also been extended to the rotary engine. After having already brought out a 110 hp. rotary engine with transmission gear, Siemens & Helske lately issued a 160 hp. 11-cyl. rotary engine. The reduction of the number of revolutions to the propeller is attained in the latter type by making the crankshaft and cylinder block work in opposite directions. They both revolve at 900 r.p.m. in opposite directions, so that the cylinder block attains 1800 r.p.m. as compared to the crankshaft. This type has the advantage over earlier rotary engines not only on account of its low unit weight due to high liter power, but also because the low number of revolutions of the cylinder star diminishes the unpleasant gyratory motion usually found in powerful rotary engines, so that the effect is no longer disagreeable. The exceptionally short climbing time attained by this engine (see Fig. 4) is due not only to the transmission device, but also to other qualities which will be described later on.

The effort made to obtain the highest possible power with the lowest cylinder capacity, that is, with the least possible weight, has also led to the bestowal of more attention on the two stroke cycle. In spite of the evident advantages it offers, the development of the two-stroke cycle system has been neglected in comparison to the 4-stroke cycle engine, chiefly because of the great supply of heat in the cylinder and the high number of revolutions to be considered, which caused serious difficulties. The quantity of heat supplied to the cylinder wall and the piston head at the time of combustion is surprisingly large. Calculated on the base of the area unit, it is, for instance, ten times as great as that of the fire-box

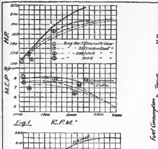


Fig. 1 R.P.M.

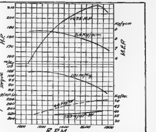
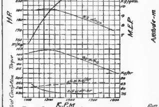


Fig. 2 Power Curve of 6 Cyl. Benz Engine Nominal Horsepower 185.



R.P.M.

Fig. 3 Power Curve of Benz 195 H.P. 8 Cyl High Speed Vee Engine

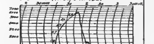


Fig. 4

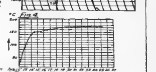


Fig. 5 Temperature Variation of Pistonhead.

Figs 6 & 8. Relation between M.E.P. and R.P.M.

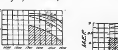


Fig. 6 R.P.M.

Figs 6 & 7 Test on 200 H.P. Benz Eng. No. 30,656.

Fig. 7. Compression Ratio.

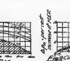


Fig. 8 R.P.M.

Figs. 8 & 9 Test on a 200 H.P. Benz Engine No. 32524

Fig. 9 Compression Ratio

Figs. 7 & 9 Comparison of the actual and theoretical increase of M.E.P. with increase of Compression Ratio

of a locomotive. This explains the necessity for such a high degree of durability in the cylinder and piston of many types of engine. In the two-cycle engine, these difficulties are even greater, twice as many combustions taking place with the same number of revolutions, so that twice the amount of heat must be applied to the same cylindrical dimensions per unit of surface. Prof. Junkers has now developed the portions subjected to the influence of the hot gases in such a way that those portions can be effectively cooled. Another difficulty to be encountered is the scavenging of high-speed two-cycle engines. Mixed scavenging is not successful in most cases. Pure air scavenging necessitates, on the other hand, the direct injection of the fuel into the cylinder. The constructive difficulties thereby entailed have been overcome by Junkers' high-pressure fuel pump, which regulates the quantity of the mixture.

The Junkers Two-Cycle Engine

Prof. Junkers's aviation engine is constructed with pistons placed in opposite directions, as in the case of the well known Junkers oil-engines. Two pistons move in opposite directions in one cylinder, the combustion chamber being enclosed in their inner dead center. Near the outer dead center, the piston control ports in the cylinder wall, through which fresh combustion air is let in and the consumed gases exhausted. Several cylinders of this kind lie parallel to one another. All the pistons lying in the same direction drive a common crankshaft. The regular working of the pistons and the accuracy of their intake and exhaust control is ensured by coupling the crankshafts by means of spur wheels. The engine power is supplied through the projected shaft of the middle spur wheel, on which the propeller is generally fixed. This arrangement has the additional advantage of enabling the best number of revolutions to be given to the propeller shaft, by alteration of the transmission in the spur wheels, independent of the number of revolutions of the engine.

The crank gear is disposed in two cases, which fill up the outer longitudinal side of the machine. The spur gear is entirely enclosed in a separate case closely adjoining the charging pump, which is projected to form the gyratory piston pump for the admission of fresh air. The pipes for the inlet of scavenging and charging air and for the outlet of exhaust gases also extend over the cylinders, the first-named pipe being constructed on the case of the charging-pump.

The pistons are equipped with a singular cooling device. The cavity of the piston is partly filled with heavy oil fluid which is not renewed in working and is violently dashed backwards and forwards by the motion of the piston. The fluid thereby absorbs the heat of the piston head and discharges it on the cylindrical portion of the piston, which conducts it into the cooled cylinder jacket.

The efficacy of this piston cooling has been proved by measurements taken with thermo-elements. Fig. 5 shows how the temperature of the piston-head gradually rises and attains the inertia condition after 18 min. This cooling system held good at speeds amounting to 2000 r.p.m. and also during longer periods of working.

The Junkers engine has another peculiarity, namely, that all the valves that cause great difficulties in high-speed engines with increasing cylinder capacity and thereby limit the working of the cylinder to some extent, are avoided by means of distribution through port-holes.

The valveless method of construction thereby makes it possible to construct reliable light engines with high cylinder power.

The balancing of the masses attained by the disposal of the pistons in such a manner that they work in opposite directions is of importance with regard to the utilization of the light-weight engine, and it can easily be brought to perfection by the requisite disposition of the pistons. Combined with the good conditions under which the cylinder charge is renewed, it becomes possible, with such favorable balancing of the masses, to obtain a high number of revolutions and to reduce the unit weight still further in consequence. As compared to other two-stroke engines, the Junker has the advantage of being able to attain high mean pressures and, in consequence, high powers with given dimensions. This is seconded by the complete scavenging of the cylinders and the high compression of the charge, which can, by reason of the absence of over-heated portions of the combustion chamber, be admitted with advance ignition without risk. Another favorable point is the slight loss of heat due to the smallness of the cooling surface of the combustion chamber.

Hellmuth Hirth is now making tests with an engine that is quite unique in its way. It is a two-cycle engine, which has no actual scavenging or charging pump. The exhaust gases are drawn off through the hollow steel propeller, its peripheral speed being utilized for the production of a vacuum. This vacuum not only carries off the exhaust gases, but also simultaneously inducts the fresh charge into the cylinder. The obstacles to be overcome in the case of the engine consisted in the construction of a suitable steel propeller and in the transmission of the hot gases from the stationary cylinder to the rotating screw. Both points have been cleverly disposed of by Hirth. The cylinders, disposed in star form, and the control are fundamentally similar to those of the Junkers engine, excepting that the cylinders are curved around the combustion chamber in such a manner that the courses of the pistons are parallel. The mechanism is so disposed that the pistons first expose the exhaust orifices and then the intake orifices. The cylinders being charged only by the vacuum produced by the peripheral speed of the propeller, it might be concluded that there would be difficulty in starting the engine. This is not the case, however. The screw is simply turned, at starting, in the direction contrary to the usual one, a depression is thereby produced, in the combustion chamber, which enables the combustion mixture to enter through the inlet orifice thereby exposed. This engine, too, is supposed to run at high speed with gear, with 2400 r.p.m. at the crankshaft. The weight of a 300 to 400 hp. engine should amount to 0.75 to 0.8 kg./hp. including the water and oil in the engine. The method of abducting the exhaust gases through the propeller may also be applied to 4-cycle engines. A better degree of admission can be obtained by this means, and higher mean pressure and power are attainable in consequence.

(*To be concluded*)

Pressure Distribution Experiments

In an article contributed to a recent issue of *L'Aeronautique*, of Paris, A. Toussaint and Lieutenant Weisenberger describe some experiments that were made at the Aerotechnical Laboratory at St. Cyr, France, to determine the pressure distribution around cylinders with the axes perpendicular to the wind direction. The experiments were made upon cylinders 14 mm. in diameter in a channel 250 mm. in diameter.

The pressure distribution was observed round the median section in two cases — (a) With a cylinder 100 mm. long, (*b*) with a cylinder 250 mm. long, *i. e.*, extending right across the channel and, therefore, equivalent to an infinitely long cylinder. The pressure region on the front of the cylinder was found to extend over an angle of 83 deg. in case (a) and 75 deg. in case (*b*). The suction in case (*b*) was a maximum at angles of 70 deg. with the wind. It decreased in value from 70 deg. to 90 deg. and was sensibly constant from 90 to 180 deg. The absolute values of the suction were greater in case (*b*) than in case (*a*). The pressure at any given angle was proportional to the square of the speed, whereas the suction was not.

Experiments were also made upon three cylinders of diameters 11 m., 18 mm., and 20 mm., 100 mm. in length, to determine the angle at which the pressure changed from positive to negative. These angles were found to be 36.5 to 37.25 deg.; 47.2 to 46.75 deg., and 45.5 to 46.5 deg. respectively. If the angle over which the pressure region extends is plotted against the ratio L/D it is found that the angle decreases with increasing L/D up to $L/D = 10$ after which it remains constant at about 75 deg. In the case of the 100 mm. by 14 mm. cylinder, the pressure distribution around a section situated near one end was also observed and was found to differ somewhat from the distribution on the central section.

New Bleriot "Mammoth" Tested

On August 18 the Bleriot triplane "Mammoth," with four Hispano-Suiza engines, which has been entered for the French government competition, was flown by M. Jean Casale for ten minutes at a height of 25 meters.

New Ansaldo Transport Airplane

Sketch of the Ansaldo A-300 C Transport Airplane (300 Hp. Fiat Engine) Which Accommodates Four Passengers Beside a Crew of Two Men

A new single engined machine for air transport will shortly be put on the market by the Aero Import Co. This is known as the Ansaldo A. 300 C and is designed especially for the rapid, safe and reliable transport of passengers.

The machine is a tractor biplane equipped with a Fiat A 12 bis 300 hp. engine. The crew consists of a pilot and mechanic who are placed in a separate cabin behind the engine and provided with a very good field of vision. Four passengers are accomodated in a commodious cabin at the trailing edge of the wings. Large windows give good vision and both cabins have doors. The cabin portion of the fuselage completely fills the space between the wings and is faired into the wing roots. The uper and lower wing roots are of equal span and the upper and lower wings on each side are similar except for fittings.

The landing gear, the central portion of the fuselage and the wing roots form a unit. The wheels have a wide track, which allows the designer to eliminate the wing skids. The axle fairing is a lifting surface. The engine section can be removed bodily. This also assists in making replacements in service. The same thing is true of the aft portion of the fuselage. The wing roots are braced to the body by faired steel tubes. The engine section is covered with aluminum, the cabins with wood and the tail with cloth.

The rudder is balanced and the tail plane incidence is adjustable by the pilot in flight to allow for variation in load. The speed is 112 m.p.h. The weight with fuel is 2535 lb. and the permissible load is 1653 lb. The fuel carried is sufficient for a flight of five hours. The span is 43 ft. 10 in., the length overall is 32 ft. 3 in. and the height overall in flying position is 10 ft. 8 in. The total supporting surface is 473 sq. ft. This gives a wing loading of 8.85 lb. per square foot with maximum permissible load, and a power loading of 13.76 lb. per horsepower under the same conditions.

New Schuette-Lanz Construction

The latest type of Schuette-Lanz Airship has a capacity of 2,048,360 cu. ft. and an overall length of 650 ft. 8 in., with a maximum diameter of 75 ft. 6 in. It is provided with five 240 hp. Maybach motors which give it a maximum speed of 62 m.p.h. The carrying capacity is 37.5 tons.

The hull consists of 19 principal rings 32 ft. 10 in. apart, connected longitudinally by lattice girders of hard drawn duralumin tubes, these being in turn interconnected with lattice frames and light intermediate rings. This design makes it possible to anchor the engine gondolas to the main rings both horizontally and vertically and secures sufficient rigidity for the engines and propellers. The latest design of lateral engine gondola contains two motors driving one propeller and is totally enclosed.

The total weight of the airship, complete with five motors and four gondolas, is as follows:—

18 gas bags . . .	3,380 tons
Covering for framework	1,670 tons
Keel surfaces and rudders	1,070 tons
Engine and pilot gondolas	1,860 tons
Safety appliances and steering gear	340 tons
Motors and machinery .	4,540 tons
Petrol tanks and piping .	480 tons
Tanks for water ballast	350 tons
Suspension ropes and stays for the gondolas, stay ropes, signal arrangements, lighting equipment, wireless, etc. .	1,030 tons
Hull with lattice bracing . .	12,900 tons
Total weight	27,820 tons

The gas bags ave made of specially prepared cotton material to which gold-beater's skin is secured by waterproof glue. It has the advantage of being practically proof against leakage and very light. The weight saved by the use of this material in preference to the rubber impregnated cotton used for the first Zeppelins amounts to 6 tons in the case of a ship of 2,048,360 cu. ft. capacity. Great progress has been made in the manufacture of this material during the war.

Wood is still the material used for the framework of airships up to a capacity of 1,300,000 cu. ft. The use of duralumin effects a saving in weight of from 20 to 30 per cent, as compared with wood.

The water ballast tanks are suspended in the interior tunnel corridor and consist of bamboo frames covered with waterproof cloths each containing 0.50 to 1.00 tons of water. (D. Ruehl, *De Ingenieur.*)

The Federated American Engineering Societies

The Federated American Engineering Societies is constituted of engineering and allied technical organizations, whose chief purpose is the advancement of the knowledge and practice of engineering and allied technical arts, which are not organized for commercial purposes. It includes the individual engineer and the allied technologist who is represented through the society or societies of which he is a member, which have membership in the organization. It includes civil, mining, metallurgical, mechanical, electrical, testing, railway, highway, municipal hydraulic, sanitary, water works, bridge, agricultural, illuminating, heating, ventilating, refrigerating, safety, radio, fire protection, automotive, industrial, military, marine, naval and chemical engineers, and architects, naval architects, chemists and geologists. These branches of engineering and allied sciences cover the whole range of activity in this country upon which is dependent its economic success.

Formation of The Federated American Engineering Societies

Engineers and allied technologists have been content to perform their work without notoriety. Dating from a period considerably before the war, the engineer was gradually developing class consciousness, and a desire to be of public service. This desire was intensified as a result of the World War and led to the formation of Engineering Council by the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers, the American Society of Mechanical Engineers, and the American Institute of Electrical Engineers. In the effort of these societies to determine in what way their activities could be improved and rendered of greater value, committees were appointed by each, and these committees in turn appointed Conferees, who met and organized the Joint Conference Committee. As a result of this intensive desire for service, it was the unanimous opinion of the Joint Conference Committee that a comprehensive organization was desirable that could speak for the engineering and allied technical professions wherever engineering experience and technical training are involved, as well as in matters of common concern to these professions. This recommendation was accepted by the constituent societies who authorized the Committee to call, without delay, a conference of representatives of national, local, state and regional engineering organizations and affiliations for the purpose of bringing into existence the comprehensive organization recommended. The Committee issued a call to 110 engineering and allied technical organizations for the Organizing Conference of June 3-4, 1920. This organizing conference unanimously created The Federated American Engineering Societies and authorized the Joint Conference Committee to act as the Ad Interim Committee between its adjournment and the first meeting of its governing body, American Engineering Council.

Publications of the Joint Conference Committee

Immediately following the Conference, the Joint Conference Committee issued a formal invitation to each organization, originally invited to the Organizing Conference, to become a Charter-Member of The Federated American Engineering Societies, and to appoint delegates to the first meeting of American Engineering Council to be held on November 18-19 at the New Willard Hotel, Washington, D. C.

The offices of The Federated American Engineering Societies and of the American Engineering Council are in the Engineering Societies' Building, 29 West 39th Street, New York.

The Lacoin-Damblanc Helicopter

Some interesting information regarding the Lacoin-Damblanc helicopter, of which mention has been made in these columns before, is given by Ernest Archdeacon in a recent issue of *L'Aerophile*.

This machine is constructed in the form of a tractor fuselage, complete with two engines in tandem, landing gear and tail surfaces. In the region of the engine a system of steel struts supports on either side a large horizontal lifting screw which is formed of four blades of aerofoil section.

M. Archdeacon states that in commencing a flight the pilot starts up the motor and gradually throws in the clutches connecting them to the airscrews, the blades of which are initially at O deg. incidence. He then gradually increases the blade incidence until the thrust becomes greater than the total weight, at which stage the machine rises. The pilot can control the speed of ascent by means of the variable airscrew pitch.

Having attained the desired altitude, the pilot works the controls so that the airscrew blades behind the axis are given a greater incidence than those in front. This has the effect of moving the axis of resultant thrust back behind the C.G. so that there is a pitching couple on the machine. The latter, therefore, tilts forward so that the axis of thrust is now inclined and has a forward component which will give the machine a translational velocity, while the weight is balanced by the vertical component of the thrust. M. Damblanc estimates that with an angle of inclination of 10 deg. the value of the horizontal component of the thrust will be 300 kg., and that the head resistance of the whole machine is equal to that of a flat plate of 1.5 sq. m. area normal to the direction of motion. Under these conditions he deduces that the forward speed attained will be 160 km.p.h. (111 m.p.h.). In horizontal flight steering is the same as in the case of an ordinary airplane.

If one of the engines cuts out the other will drive the two screws at a sufficient rate to ensure slow descent. If both engines fail, the airscrews will rotate as windmills and the inventors anticipate that by adjusting the blade incidence and the stabilizing planes the pilot will be able to cause the machine to descend in a normal glide.

Transport Airplane L.V.G.-G. III

This machine, which is fitted with two 260 hp. Maybach engines, is a triplane having the following leading characteristics:—

Area of wings	115.2	m.
Length of machine	10.25	m.
Height	3.9	m.
Span	24.5	m.
Engines	2	Maybach 260-hp each
Weight, empty	2,960	kg.
Weight full (pilot, 3 passengers, fuel and oil for 5½ hours' flight	4,100	kg.
Speed in horizontal flight	130	km./hr.
Landing speed	60	km./hr.
Time of climb to 3,000 m.	20	min.
Radius of action	700	km.
Wing loading	35.7	kg./sq. m.
Hp. loading	7.9	kg./hp.

The fuselage is constructed of wood covered with three-ply. The two engines are mounted in power eggs on either side. They form the terminal points of the center section. The top and bottom wings are in three parts, the outside portions being at a slight dihedral angle to the central portion. (*Flugsport*.)

The Commercial Aerofoil

In an article contributed to *Aircraft Engineering*, of London, F. E. Cowlin investigates the effect of applying a hypothetical aerofoil to an airplane having certain fixed characteristics, and on this basis draws certain conclusions regarding the effect the use of such an aerofoil would have on the cost per unit load.

According to Mr. Cowlin, it appears advisable from the commercial standpoint that research should be conducted on aerofoils of the high-lift type with a view, firstly, to remove the difficulty of lateral control hitherto experienced, and secondly, to develop a wing section having high-lift characteristics without loss of efficiency at cruising speed. The probability of obtaining such results cannot be affirmed or denied on the evidence at present published, but the lack of data does at least suggest the possibility. The reduction of cost per ton-mile alone is ample justification, since thereby the scope of commercial operation would be considerably enlarged.

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